# Australasian Plant Conservation

BULLETIN OF THE AUSTRALIAN NETWORK FOR PLANT CONSERVATION

VOLUME 15 NUMBER 4 • MARCH - MAY 2007

Ectomycorrhizal fungi - vital components of Australia's biodiversity
Are diverse mammal communities important for maintaining ecosystem health
Soil and litter invertebrates, *Acacia* and plant growth in revegetated systems
Translocation of Leafy Greenhood *Pterostylis cucullata*
And much much more………

## SPECIAL THEME: 'WHAT LIES BENEATH?'

# This issue

From the Editor: introducing 'What lies beneath?' 1

From rainforest remnants to cryptic soil biota 4

Abstracts of papers presented to the ANPC National Forum 7

Linking the above-ground to the below ground 11

Ectomycorrhizal fungi – vital components of Australia's biodiversity 13

Are diverse mammal communities important for maintaining ecosystem health 16

Soil and litter invertebrates, *Acacia* and plant growth in revegetated systems 19

Translocation of Leafy Greenhood *Pterostylis cucullata* 21

Environment (and agriculture) the big loser in closure of CRCs 23

# Regular Features

Report from NZ Plant Conservation Network 26

Book and DVD Review 27

Research Roundup 28

Information Resources and Useful Websites 29

Conferences and Workshops 30

***Australasian Plant Conservation***

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*Australasian Plant Conservation* is produced by the ANPC Inc. with assistance from the Australian National Botanic Gardens.

*Australasian Plant Conservation* is printed on recycled paper.
ISSN 1039-6500

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## ANPC Inc. Mission Statement

*"To promote and improve plant conservation"*

## Contributing to *Australasian Plant Conservation*

*Australasian Plant Conservation* is a forum for information exchange for all those involved in plant conservation: please use it to share your work with others. Articles, information snippets, details of new publications or research, and diary dates are welcome. **The deadline for the June-August issue is Friday 29 June 2007.** The June-August issue will be on the special theme of 'Taxonomy and plant conservation'. However, general articles are also very welcome. Please contact Tom May if you are intending to submit an article: tom.may@rbg.vic.gov.au.

Authors are encouraged to submit images with articles or information. Please submit images as clear prints, slides, drawings, or in electronic format. Electronic images need to be at least 300 dpi resolution, submitted in at least the size that they are to be published, in tif, jpg or gif format. Guidelines for authors are at: http://www.anpc.asn.au/anpc/pdffiles/APCGuideContrib.pdf.

Please send typed or handwritten articles, no more than two A4 pages (or 1100 words), by fax, mail, email, or on disk. If sending by email, please send as a MS Word (2000 compatible) or rich text format attachment to: tom.may@rbg.vic.gov.au.

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**Front cover:** Biotic soil crust with lichens and bryophytes. Photo: Cassia Read.
**Cover design:** Siobhan Duffy.
**Printed by:** Pirion, Canberra.

# From the Editor: introducing 'What lies beneath?'

*Tom May*

*Royal Botanic Gardens Melbourne. Email: tom.may@rbg.vic.gov.au*

This issue focuses on the theme of the recent ANPC National Forum on the topic of 'What lies beneath? The role of soil biota in the health and rehabilitation of native vegetation.'

The Forum concentrated on the soil biota traditionally classified as plants (the blue-green algae, fungi, lichens, mosses, liverworts and hornworts). These share usually small to microscopic size and are often referred to as 'non-vascular plants', 'lower plants' or 'cryptogams'. In fact they belong to a number of the kingdoms of living things: blue-green algae are bacteria (cyanobacteria), fungi comprise a separate kingdom (which also includes lichens), and the bryophytes (mosses, liverworts and hornworts) are plants. This taxonomic diversity is indicative of their varied and vital roles in ecosystems, such as decomposition of organic matter, partnerships with plants through mycorrhizas, and formation of biotic soil crusts.

Among many very interesting pieces of information in Forum presentations, David Eldridge pointed out that effective rainfall for rangeland shrubs is increased by run-off from the biotic soil crust that occurs in the spaces between the shrubs. A report on the Forum appears in this issue, along with abstracts of papers presented, and there are also several papers in this issue which are based on Forum presentations. For other articles relevant to the topic see also previous issues of *Australasian Plant Conservation* on the themes of 'The forgotten flora remembered', APC 14(1) for June-August 2005, and 'Conserving symbioses', APC 15(2) for September-November 2006.

In a thought-provoking paper not presented at the Forum, but very much on the theme, Andrew Claridge argues for 'Linking the above-ground to the below-ground' and makes a case for 'why we should be restoring processes as well as species in our revegetation efforts'. One of the processes that Claridge highlights is the relationship between plants and fungi through mycorrhizas (literally 'fungus-roots'). Neale Bougher surveys the diversity and roles of a specific group of these fungi, the ectomycorrhizal fungi, that are common in woodlands and forests across Australia. Karl Vernes discusses another of the processes highlighted by Claridge, the interactions between mycophagous (fungus-feeding) mammals and ectomycorrhizal truffle fungi. He makes the point that there are many mycophagous mammals, and considers what might occur when the mammal community that disperses truffle spores is depauperate or missing.

It is important not to focus only on plants, but to consider the full range of interactions among organisms in native vegetation, and several presentations at the Forum dealt with interactions with animals, both vertebrates and invertebrates. Several are covered in the printed abstracts, and in addition Mark Bourne and co-authors describe experiments assessing the beneficial effects of soil and litter invertebrates on plant growth, in revegetation where *Acacia* is grown alongside *Eucalyptus*.

The Forum served to raise the profile of soil biota and disseminate information about their important roles, but also to encourage interactions among the people carrying out research on the organisms and interested in applying knowledge to on-ground practice. Two discussion

## Editor, *Australasian Plant Conservation*

The position of Honorary Editor of *Australasian Plant Conservation* will become vacant in January 2008.

The main tasks of the Editor are to:

- organise themes for APC, in consultation with the ANPC Committee;
- recruit authors, and ensure promised articles are provided by deadlines;
- edit (or assign articles for editing to team of copy editors); most articles require only minor editing of the text; and
- compile articles and images (checked for resolution) for graphic designer.

The tasks could be split into a Commissioning Editor and a Production Editor.

There is a team of volunteer copy editors and proof readers, who provide excellent support to the Editor. Layout and design is done by a professional graphic artist, and liaison with the printer is carried out by ANPC office staff.

Ideally, the new Editor will overlap with the current Editor for at least one issue to learn the ropes.

Please contact Tom May for further details of the position (tom.may@rbg.vic.gov.au; 03 9252 2319) sessions on the Wednesday of the Forum dealt with the conservation of cryptogams and the prospects for ‘adding soil biota to the rehab recipe’. The main points from these discussions are summarised below.

It is quite clear from the presentations to the Forum that the hidden soil biota cannot be ignored in revegetation and rehabilitation. Some significant challenges remain, including how to increase the knowledge base on these often overlooked organisms, and how to apply the knowledge to on-ground practice.

One aspect that became apparent when listening to the various talks during the Forum on soil biota is that relatively intact bushland, with its hundreds (perhaps thousands) of species of bacteria, invertebrates, fungi, lichens, liverworts and mosses is a treasure to be greatly valued. It is easy to overlook these organisms because they are usually small and cryptic, but they play such important roles, and provide great resilience to bushland.

It would be very interesting to see an estimate of the cost of fully restoring a hectare of native bush from a cleared site. It is quite feasible to successfully replant the dominant trees, but to bring back the full complement of species (including all the fungi) could well run into hundreds of thousands of dollars or more and take several lifetimes!

Following the soil biota articles, Russell Mawson describes a recent translocation of the endangered greenhood orchid *Pterostylis cucullata*. It is very useful to document this kind of activity, a point also made by Zoe Smith in her Forum presentation. Future issues of *Australasian Plant Conservation* are planned to encourage more reporting of trials (to learn from successes, and also failures) and to encourage community groups to document their efforts in plant conservation, such as through translocation, rehabilitation and revegetation.

The final article is a sobering report on the uncertainty about the future of several of the Australian Cooperative Research Centres, including the CRC for Australian Weed Management. The Weeds CRC has many significant achievements and initiatives in both the environmental and agricultural sectors and it is to be hoped that a way can be found, such as through a National Weed Centre, for its vital work to continue.

# SUMMARY OF DISCUSSIONS AT ANPC NATIONAL FORUM, CANBERRA, APRIL 2007

*A wide range of issues was discussed by two discussion groups during the ANPC National Forum. The main points raised are summarised below.*

## CRYPTOGAM CONSERVATION

This group considered the current conservation status of cryptogams (non-vascular plants) and prospects for advancing that status.

### Formal listing of cryptogams under national and state conservation laws

- Non-vascular flora warrant the same level of protection as ‘higher’ plants.
- Cryptogams can be nominated for listing but relatively few are included on current lists.
- The main barrier to species being nominated is poor knowledge.
- Assessment criteria such as estimation of population size can be difficult to apply to cryptogams.

### Poor knowledge base about cryptogams

- Few scientists/taxonomists specialise in cryptogams in government institutions (state botanical herbaria, universities, CSIRO, conservation management agencies).
- Lack of tertiary courses in mycology, bryology etc.
- State agencies give cryptogams a low priority when doing surveys.
- There appears to be great potential for community input, such as exemplified by Fungimap, the Perth Urban Bushland Fungi Survey and the Sydney Fungal Studies Group. However, community activities are often catalysed by input from experts and hence limited by their availability.
- Could expand Fungimap to include lichens.
- Scope to raise community awareness of existing resources (such as Fungimap, Australia’s Virtual Herbarium, ANBG fungi website, ABRS publications, Sydney Fungal Studies website etc.).

### Other approaches to cryptogam conservation

- There is an assumption that conservation of the vascular plant community acts as an umbrella for the poorly known cryptogams, but this needs to be tested.
- Cryptogamic hot spots could be identified (an example is the community of waxcap mushrooms at Lane Cove, Sydney).
- Raising awareness of cryptogams throughout the general community could assist conservation efforts.

## ADDING SOIL BIOTA TO THE REHAB RECIPE

This group discussed how to apply our knowledge of the ecological roles of soil biota to on-ground rehabilitation practice; considered what we can and cannot do; and identified knowledge gaps.

### Techniques and provenance for inoculation of microbial taxa in revegetation

- Current use of spores or bacteria for reintroduction is based on small number of species, or elite strains, despite enormous diversity.
- There may be propagules already present in soil, so inoculation not always necessary.
- Is there potential for mixed species inoculations?
- Can mammal faecal pellets be used as source of spores?
- Do not use soil from intact remnants for inoculation (danger of spreading pathogens, and don't want to disturb the soil in 'good' bush).
- Trials are good, but there is also immediate need to integrate methods in large scale restoration (based on whatever knowledge available).
- Need to investigate guidelines for provenance and collecting of soil biota.

### Information on using cryptogams in revegetation

- Information is scattered.
- Information needs to be provided both in technical literature and also as practical level knowledge for getting things done on the ground.
- Mine site restoration is one example where not much published.
- Publication of trials needs to be encouraged (even when negative results).
- Trials need to have good experimental design to allow statistical analysis (general advice needed on this).
- Must train the next generation of scientists, through university courses.
- Need workshops and field trips, to transfer knowledge and give key ideas and basics for action at a local level.
- Landholders who adopt use of soil biota in rehabilitation can be influential to their peers.

*Participants in the discussion on cryptogam conservation at the ANPC National Forum. Photo: Sally Stephens*

### Importance of research to underpin use of cryptogams in revegetation

- Need to look at the whole system and its interactions rather than individual species or groups of organisms.
- For funding and research try and shift focus to outcomes (such as functioning, diverse and resilient ecosystems) rather than merely outputs (such as trees planted).
- Need to look at question of redundancy – for example, different mosses with different morphology may have similar functional attributes; are the full suite of species required for a healthy ecosystem?
- Dormancy of propagules (such as of spores in spore prints) needs investigating.
- What happens with loss of mammals that disperse mycorrhizal truffle spores?
- Need more information about effects of herbicides on cryptogams.
- Work on cryptogams in revegetation needs to be expanded across full range of ecosystems – from grasslands to alpine areas, and include natural environments as well as modified ones.
- Collaboration important, but lack of specialists: 'taxonomists – we need them!'.

### ACTIONS FOR THE AUSTRALIAN NETWORK FOR PLANT CONSERVATION

The following suggested actions for ANPC arose from the two discussion groups at the National Forum.

- Host a Cryptogam Conservation Working Group, as a collaboration between all existing national non-vascular bodies and interested, active local groups, which could develop an updated Conservation Strategy for Australian Cryptogams, with specific objectives.

- Gather and disseminate information on cryptogams and their conservation, and their use in revegetation, such as on the ANPC website and through a regular section in *Australasian Plant Conservation.*

- Examine the need for guidelines and protocols for use of cryptogams and other microscopic biota in revegetation (such as in relation to gathering and provenance of spores), and, if required, coordinate development of guidelines.

# From rainforest remnants to cryptic soil biota

*Sally Stephens*

*Australian Network for Plant Conservation. Email: sally.stephens@anpc.asn.au*

The Australian Network for Plant Conservation has had yet another intensely busy period, planning, organising and delivering another rehabilitation workshop and our first National Forum, both of which were very stimulating and well-received.

## Coffs Harbour, 14-15 March

## Workshop on the rehabilitation and management of disturbed native plant communities

The downpour was so intense that the plane needed two attempts to land at Coffs Harbour airport. This wasn't looking promising for our field trip and I had no plan B! Luckily, the skies cleared for the workshop – another sunny field day in a long run of ANPC events.

This was our second recent NSW coastal region workshop. See APC 15(3) pp 2-3 for the report on the first, held at Ulladulla in October 2006. The Coffs Harbour workshop was our biggest workshop yet, with 111 people registering, several of them days after the closing date. You just can't turn away people keen to come all the way from Christmas Island, can you?

The program was similar in structure to the Ulladulla workshop, but focused on issues relevant to the NSW north coast. Our first speaker was Pastor Ben Bird of the Gumbula Julipi Elders Group, who welcomed us to Country. A range of highly experienced presenters then spoke on ecological principles, planning, vegetation condition assessment, soil characteristics, provenance of plant material and monitoring and adaptive management – all from the perspective of rehabilitation practice. Other topics included North Coast Endangered Ecological Communities (EECs), case studies on coastal wetland rehabilitation at Nambucca and Bellinger Rivers and also Urunga Lagoon, and a summary and discussion of the Border Ranges Hotspot Rainforest Multi-species Recovery Plan involving Queensland and NSW landholders, community groups, researchers and agencies. Work on Bell Miner-associated dieback in woodlands and forests and a possible relationship with dense understorey lantana was outlined; this meshed well with the demonstration of the 'splattergun technique' for lantana control during the field excursion.

The field trip on the second day took us to the Jetty Dunecare rehabilitation site at the Jetty area of Coffs Harbour. This site admirably demonstrates the achievements of an energetic community group battling serious urban development pressures. Discussions on weed control and some local plant identification added to the diversity of issues covered. The next site was Coramba Nature Reserve, a stark contrast to the Jetty beach front. About 20 minutes north-west of Coffs Harbour, the nine hectare reserve sits amid cleared grazing land. Although small, the reserve is significant as it contains one of the few remaining stands of 'lowland rainforest on floodplain', listed as an endangered ecological community under the *NSW Threatened Species Conservation Act 1995.*

Here the group rotated around four activities, covering bushland condition assessment, monitoring, manipulating regeneration in weed-dominated sites and soil analysis. A hot but happy and well-fed crowd gathered back at the buses for the return to Coffs Harbour.

This workshop, like its Ulladulla precursor, was subsidised by the NSW Environmental Trust, which is gratefully acknowledged for its frequent support of the work of the ANPC.

## ANPC National Forum - Canberra 17-19 April

## What lies beneath? The role of soil biota in the health and rehabilitation of native vegetation

At the ANPC's Adelaide Conference at the end of September 2005, the Committee decided to hold a National Forum in the year between its biennial Conferences. This first National Forum, organised and coordinated by a small working group and a host of advisers, was a resounding success. From an original concept of a shorter and simpler event than the Conferences, it grew to occupy three very full days of dynamic talks, group discussions, practical workshops and field excursions.

The primary focus of the Forum was on the hidden and often-overlooked soil-based flora: mosses, liverworts, fungi and lichens. Soil fauna were also included, and some plant-fungi-animal interdependencies were described. An outstanding group of presenters, workshop and field leaders guided the participants through explorations of the types of organisms, their key roles in ecosystem function and relevance to native vegetation rehabilitation.

### The Forum program

Day 1: presentations on the diversity of soil biota and their roles in ecosystem function;

Day 2: panel discussions and practical workshops;

Day 3: field excursion.

### *Day 1: Presentations*

A suite of expert biologists shared their knowledge and latest research findings and described efforts to apply all this to on-ground rehabilitation practice. This is perhaps the most challenging aspect with no simple answers. As one presenter noted, he is always asked 'where do I buy the microbes?' Some experiments on planting success after inoculating seeds with rhizobia or mycorrhizal fungi were presented – such experiments hold the key to increasing knowledge on how to improve rehabilitation success through the activity of soil biota.

Topics covered biological soil crusts, disturbance, vegetation recruitment, mycorrhizal fungi and orchid reintroductions, ectomycorrhizal fungi and restoring biodiversity, arbuscular mycorrhizas, bryophyte conservation, fungi in agricultural landscapes, plant-rhizobial interactions, the role of mammals in dispersing fungal spores in woodlands, managing invertebrate/fungal interactions with fire, and soil invertebrates in ecosystem function – these abbreviated titles attempt to summarise the stimulating talks of the first day. Full versions of some papers from the Forum are included in this issue, along with abstracts of all the other talks (pp 7-10).

### *Day 2: Panel discussions and practical workshops*

Participants chose between two discussion sessions in the morning:

1. Conservation of the 'forgotten flora': progress, gaps, priorities.
2. Adding soil biota to the rehab recipe: how to apply our knowledge of the ecological roles of soil biota to on-ground rehabilitation practice; what we can and cannot do; identifying knowledge gaps.

Each group provided a short summary of the discussion outcomes. The main points from the discussions are summarised on pp 2-3, and the summaries will be provided on the ANPC website with other forum information in the near future.

Participants then chose two out of eight available workshops, with four running concurrently in the morning and another four in the afternoon:

A. Practical aspects of using mycorrhizal fungi in revegetation
B. Sampling and identification of mycorrhizas
C. Practical aspects of using bryophytes in revegetation
D. Practical aspects of using rhizobia in revegetation
E. Moss identification
F. Lichen identification
G. Liverwort identification
H. Fungi identification.

Because of numbers, workshop A was repeated in the afternoon, while workshops E and G were combined. Most workshops were held in two ANU laboratories at Botany/Zoology, with stereo and compound microscopes available for detailed identification. Workshops had one to two leaders, but often knowledgeable participants helped their colleagues.

### *Day 3: Field excursion*

The field excursion was a stimulating travelling circus. We started by searching for soil organisms in eucalypt woodland on the CSIRO Black Mountain site, a short walk from our venue at the Discovery Centre. Despite the long dry spell, some fungi, lichens, mosses and invertebrates were found. A field microscope and multiple hand-lenses assisted identification.

The Australian National Botanic Gardens nursery was the next stop, with two demonstrations, one of inoculation of seedlings with rhizobia and the other of inoculation with mycorrhizal fungal spores. These techniques have been used in trial plots in revegetation sites, to test whether growth and survival are enhanced.

The Rainforest Gully in the Gardens was our next site, proving a welcome moist contrast to the dry woodland of our first stop. There was much to see here, with mosses, liverworts, fungi and lichens abundant and relatively lush.

After a picnic lunch on the Brittle Gum Lawn, we boarded the bus to visit two privately owned properties near Murrumbateman, about 30 minutes north of Canberra. The first property, owned by Robert and Lorna Stephens, was the location of experimental plantings of seedlings with various inoculations of

*Simone Louwhoff (left) leading the lichen identification workshop. Photo: Sally Stephens* spores of mycorrhizal fungi. The upper root zones of two plants were partially excavated to see if any mycorrhizal fungi were present. Some evidence of mycorrhizal fungi were found on the woodland soil-inoculated eucalyptus tubestock, though none were found on the other treatment. This property had once been heavily over-grazed and degraded but its new owners are self-avowed tree lovers and are actively involved in the planting experiment.

The second property we visited has been owned by the Bain family for 25 years, and shows the results of many years of intelligent revegetation. Experiments are being undertaken here by CSIRO Entomology to find how ecosystems respond to disturbance (e.g. from grazing, weeds and increased nutrients). These experiments investigate the complex interactions between plants, soil and litter invertebrates. Some of the group visited one of these field sites at the top of a hill while others searched for cryptogams in an old woodland remnant, once a road-side verge, so never grazed. Though dry, some success was reported.

### Attendance and feedback

Some 80 people registered for day 1 of the Forum, with slightly fewer for days 2 and 3. There were 20 presenters and workshop leaders, as well as the two families who hosted our Murrumbateman property visits.

The mix of presentations, discussions, workshops and field work provided considerable opportunities for interaction and networking. 45% of the evaluation forms were returned – these are being analysed to provide information for future ANPC events. Initial examination of the forms indicates a high level of satisfaction. Verbal feedback at the time was also very positive, as has been subsequent feedback.

*Neale Bougher (under hat) excavating mycorrhizal roots at the Stephens' property near Murrumbateman. Photo: Sally Stephens*

## Acknowledgements

Thanks in particular to Tom May, the Forum co-organiser, who recruited most of the presenters and workshop leaders. Thanks also to Pam Strickland, my ANPC colleague and admin guru, and to Merryl Bradley, our invaluable volunteer. Sarah Jacob assisted generously throughout the Forum. Special thanks go to Jacqui Stol, who helped above and beyond all expectations. Others also excelled in providing advice, equipment and support. Chris Cargill of the ANBG provided laboratory equipment, the ANBG library lent us many books and posters, the ANU School of Botany and Zoology trusted us with their labs and highly valuable microscopes (thanks to Gary Mayo and Jeanette Cashin), the ANBG allowed us to use the nursery area and explore the Rainforest Gully. The property owners generously gave their time and hosted our visit to their land.

Thanks to the presenters and workshop and field leaders, without whom there would have been no Forum:

Neale Bougher
Christine Cargill
Matthew Colloff
David Eldridge
Niels Klazenga
Teresa Lebel
Elizabeth Lindsay
Simone Louwhoff
Tom May
Peter McGee
David Meagher
Cassia Read
Jo Slattery
Zoe Smith
Jacqui Stol
Peter Thrall
Dale Tonkinson
Karl Vernes
Alan York

*Elizabeth Lindsay discussing invertebrates in remnant woodland on the Bains' property near Murrumbateman. Photo: Sally Stephens*

The Forum workshops and field day were supported by the Natural Heritage Trust Australian Government Envirofund.

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# Abstracts of papers presented to the ANPC National Forum:

## What lies beneath? The role of soil biota in the health and rehabilitation of native vegetation

## Canberra, 17-19 April 2007

*Abstracts from day one of the recent ANPC National Forum are presented below in the order of presentation of papers. Full versions of some of the papers are included in this issue, and for these, only the title is given below.*

### What lies beneath: diversity, function and interactions, focusing on cryptic flora and fungi

*Tom W. May*
*Royal Botanic Gardens, Melbourne*

This talk introduces the organisms and themes of the ANPC Forum on *What lies beneath? The role of soil biota in the health and rehabilitation of native vegetation.* The focus of the Forum is the soil biota traditionally classified as plants, among which are cyanobacteria, fungi, lichens, algae, mosses, liverworts and hornworts. These share usually small to microscopic size and often reproduce by spores. Most have been lumped together as 'lower plants' or 'cryptogams', but many are not plants, rather they belong to quite different taxonomic groups, across a number of the kingdoms of living things. Recognition of the relationships of soil biota is important because different groups have quite different life cycles and ways of gaining nutrients. In particular, the fungi cannot photosynthesise, but must gain nutrients from the breakdown of organic matter or by partnerships with other organisms, such as in mycorrhizas. The many interconnections between soil biota and the more obvious plants and animals are much overlooked both in ecological research and in practical efforts at revegetation and rehabilitation. This Forum aims to draw attention to the organisms and their vital roles, and facilitate links among researchers and practitioners with an interest in cryptic soil biota.

Dermocybe splendida*, a mycorrhizal fungus of eucalypt forests. Photo: Simon Lewis*

### Biological soil crusts: critical components of soil ecosystems

*David Eldridge*
*Department of Natural Resources, c/- School of Biological, Earth and Environmental Sciences, University of New South Wales*

Soil crusts play an important role in maintaining healthy soils in arid and semi-arid grazing areas. They are formed by groups of small organisms, technically known as cryptogams, growing on or in the top layers of soil. Lichens, mosses and liverworts and cyanobacteria (blue-green algae), green algae and fungi are involved. The association with the soil is an intimate one. Crusts perform a number of services, most importantly stabilising the soil and preventing erosion, fixing nitrogen, providing habitat and food for invertebrates, assisting with water infiltration, and providing niches for plants to germinate in. Crusts are vulnerable to excessive trampling, and are killed by fire. Once disturbed, they recover very slowly. Biological soil crusts are good indicators of soil health in rangelands. The disappearance of crusts can be used as early indicators of soil damage.

See also: Eldridge, D. (2005). Biological soil crusts: nature's environmental watchdogs. *Australasian Plant Conservation* 14(1): 24-26.

### Biological soil crusts and disturbance: implications for vegetation recruitment

*Cassia Read, Jane Elith and Peter Vesk*
*The University of Melbourne. Email: c.read3@pgrad.unimelb.edu.au*

Biological soil crusts are a diverse community of cryptogams that exist at the soil surface in ecosystems of low canopy cover. Disturbances such as fire, stock trampling and vehicle traffic can cause profound changes in the cover and composition of biological soil crusts, with severe and repeated disturbances resulting in complete removal of crusts. Effects of disturbance and the recovery of crusts depend on the type, severity and timing of disturbance, site characteristics and type of crust affected. The effect of crust disturbance has important implications for management and restoration of native vegetation. Crusts modify the soil environment in ways that affect the germination and survival of vascular plants. Although our understanding of the role of crusts in vegetation recruitment is limited, some generalisations can still be made. Whether biological soil crusts inhibit or facilitate vegetation recruitment has important implications for succession following disturbance events and the long-term health of arid and semi-arid ecosystems.

*Biotic soil crust with lichens. Photo: Cassia Read*

### Ectomycorrhizal fungi – vital components of Australia's natural and restored biodiversity

*Neale L. Bougher*
*Department of Environment and Conservation, Western Australia*

See: Bougher, in this issue, pp 13-15.

### Arbuscular mycorrhizas: their function in soil and application to restoration.

*Peter McGee*
*University of Sydney*

A hugely diverse group of fungi live in association with plants.

Around 75% of all plants and plant species form internal mycorrhizas with arbuscular mycorrhizal (AM) fungi. The fungi have a root phase and they grow out into the soil. In natural ecosystems, AM fungi contribute to the productivity of the plant community, enhancing plant diversity and biomass, and improving structure of the soil. The mechanisms include exploration of the soil, and transport of minerals, especially phosphate from the soluble pool in soil to the plant.

*Spore of* Glomus*, an arbuscular mycorrhizal fungus that grows within plant roots. Photo: Peter McGee*

Mycorrhizas are extremely important for plants in Australia's mineral poor soils. AM fungi are found in nearly all soils, including coral islands, and agricultural soils. However, AM fungi disperse very slowly, thus they need to be included in restoration projects where the soil has been severely disturbed, or comes from below the original surface. In native vegetation, species that form complex fruit bodies in soil are the most common type and they are extremely sensitive to soil disturbance; in arable systems, species that form single spores are more common. The species from arable systems are relatively easy to manage, but they are not entirely suitable for restoration of native ecosystems.

### The application of orchid mycorrhizal fungi in the reintroduction of *Diuris fragrantissima*

*Zoë F. Smith[1], Elizabeth A. James[2] and Cassandra B. McLean[1]*
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Australian terrestrial orchids are dependent on association with a suitable mycorrhizal fungus for germination of seed and development and persistence of adult plants. Understanding orchid mycorrhizal associations is therefore important for developing effective conservation strategies, including the re-establishment of orchids in natural conditions.

Successful reintroductions involve developing self-sustainable populations, which relies on natural *in situ* establishment of seedlings because of natural mortality rates. Therefore, inoculation of habitat soil with mycorrhizal fungi may be an important prerequisite for the survival of translocated orchids, especially considering the patchy nature of fungi *in situ*. Further, site conditions must remain conducive to the maintenance of the mycorrhizal association post-reintroduction, but little is known about the ecological requirements of such associations. Reintroductions have been planned to conserve the terrestrial orchid *Diuris fragrantissima*, which is listed as Critically Endangered in Victoria and Australia, having been reduced to fewer than 25 plants at a single site. As the natural habitat of Australian terrestrial orchids declines, reintroductions are becoming more important as a conservation strategy, but current research is limited.

This study investigated the use of supplementary orchid mycorrhizae in the reintroduction of *D. fragrantissima*, and the ongoing survival of fungi and maintenance of mycorrhizal relationships *in situ*. Addition of mycorrhizal fungi to habitat soils only improved survival of reintroduced plants when combined with soil aeration and when planting occurred in spring, rather than summer or autumn. Source plants for reintroduction were propagated asymbiotically *in vitro* and became associated with fungi in potting media.

The fungi present in plant roots at the time of reintroduction were sufficient to support the transition from nursery to field. The persistence of actively growing symbiotic seedlings in reintroductions shows that *D. fragrantissima* can be inoculated post-germination for successful reintroduction, and symbiotic germination was not essential. Mycorrhizal relationships were maintained for over a year, and new associations were formed between reintroduced plants and fungal inoculum. These associations were restricted to individual experimental plots, showing that the fungus did not spread more than 1.5 m (distance between inoculum points) over a year. Additional results determined optimum planting season and monitoring dates, which will aid efficient use of future resources. These results may also have implications for the management of wild *in situ* orchid populations, particularly where disturbance has altered the landscape.

This study involved the largest experimental orchid reintroduction yet to be conducted in Australia, proving successful in the short term with at least 50% of the reintroduced plants surviving into their third season. Extended monitoring of the reintroduced population is required to determine the long term success, including optimising requirements for recruitment of seedlings *in situ*, by means of pollination and seed germination.

## Fungi in agricultural landscapes: implications for eucalypt woodland revegetation

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Mycorrhizal fungi are a major component of the soil microbiota in many ecosystems. Eucalypts and many other members of the Myrtaceae are highly dependent on mycorrhiza formation for survival and growth. Healthy eucalypt woodland sites generally have abundant propagules of ectomycorrhiza (EM) fungi, however sites cleared for grazing or degraded may be depleted of these fungi. Such sites are often where revegetation projects are undertaken. In such cases, acceptable revegetation or plantation performance can be enhanced by the planting of seedlings with existing good EM formation.

We undertook a one year pilot project to investigate i) the distribution of EM inoculum along a gradient from remnant vegetation into a paddock, ii) whether inoculation of nursery stock with woodland soil and/or spores is effective, and iii) the effect of different inoculation treatments on eucalypt seedling survival, growth and drought response when seedling are planted out in paddocks.

The results to date indicate that areas of paddock more than 20 m from a woodland edge are likely to have low EM inoculum potential both in terms of numbers of propagules and EM fungus species richness. Woodland soil can be an effective inoculum, but *Pisolithus albus* spores are not, at least under our experimental conditions. Inoculated tubestock planted into paddocks has not yet demonstrated a significant treatment difference in terms of planting success. Effective inoculation of tubestock may need careful management of glasshouse conditions to enhance EM formation.

See also: Stol, J. & Trappe, J.M. (2006). Fungi in agricultural landscapes: implications for eucalypt woodland revegetation. *Australasian Plant Conservation* 15(2): 15-19.

## Bryophyte conservation in Australia: facts and fictions

*David Meagher*

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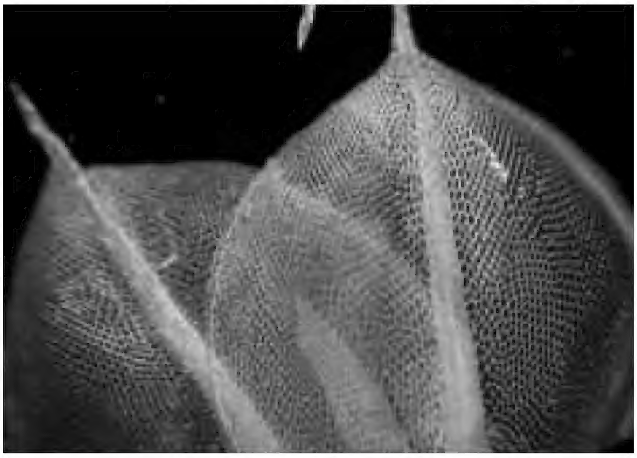
Like all native plants, bryophytes have been eligible for listing as ‘threatened’, ‘protected’ or an equivalent category under federal, state and territory legislation for many years. In 1997 a list of 150 nationally rare and threatened bryophytes was published by the Australian Government through its Endangered Species Program, but 10 years later only two bryophytes have been listed as threatened nationally under the *Environment Conservation and Biodiversity Protection Act 1999*. At the state and territory level, only Victoria, Tasmania and to some extent Western Australia have assessed the conservation status of bryophytes, and they are the only states or territories to have given specific legal protection to any bryophyte species – 15 in Victoria, two in Tasmania and one in Western Australia. Furthermore, the types of protection available in various states and territories differ greatly, as do the mechanisms in place for nominating, listing and subsequently managing species. This talk examines the legal basis for bryophyte conservation and questions whether listing really does offer the legal protection that one might expect.



*Moss leaflets under microscope. Photo: Cassia Read*

## Mammals, ectomycorrhizal fungi and ecosystem processes

*Karl Vernes*
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See: Vernes, in this issue, pp 16-18.

## Using fire to manage for invertebrate/fungal interactions and diversity

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Community attitudes towards the role of fire in the landscape are slowly changing. Wildfire is increasingly accepted as both a destructive force and a natural part of ecosystems, and prescribed fire is widely used in many parts of the world as a management tool, modifying environments to achieve specific outcomes. Is fire a tool that could be useful in ecological restoration? Scientific literature in this area is currently limited in extent. Most journal articles in recent years concerning fire and restoration focus on using fire as a tool for landscape "re-creation", reinstating some historical forest tree community that has thought to have been lost through fire exclusion. Similarly, many studies have looked at the use of fire to actively alter the composition of understorey vegetation, usually to remove weeds or other undesired species. In Australia a small number of studies have used fire to create conditions conducive to the survival of particular plant or mammal species (usually those listed as rare or endangered) or as part of post-mining landscape rehabilitation.

As well as shifting species composition towards some desired state, ecosystem restoration needs to effectively maintain or re-establish essential ecological processes, including the cycling of nutrients. Fungi and invertebrates co-occur and interact within the soil and litter; playing an essential role in litter decomposition, carbon and nutrient mineralisation and uptake, and the maintenance of soil structure. Invertebrates influence fungal communities directly through selective grazing and spore dispersal, and indirectly via litter breakdown and soil mixing. In this paper we use several case studies to demonstrate how invertebrates and fungi respond to, and recover from, fire. Response to such a disturbance sheds light on the essential environmental characteristics that influence their distribution and abundance, and in doing so, provides some broader guidelines that may assist land managers achieve important restoration goals.

## Soil invertebrates and ecosystem function in native vegetation

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Management practices for re-establishment of native vegetation often do not address the restoration of ecosystem functions and services to ensure the long-term viability of revegetation sites. This is because certain functions may be delivered by organisms that colonise revegetation months or years after it has been planted, yet it is at the planting stage that the bulk of management activity and practice is focussed.

We experimentally investigated the provision of a key ecosystem function, the facilitation of water infiltration to the rhizosphere, as delivered by invertebrate ecosystem engineers via the creation of soil macropores (small but visible holes). We measured invertebrate macropore density and water infiltration rates in revegetation sites of different ages, tree species composition and locality, compared with adjacent pastures.

We found a positive linear correlation between macropore density with age of the revegetation sites but not with geographical location or tree species composition. Water infiltration rates in revegetation sites aged 11-20 years were double those of the adjacent paddocks and of sites aged 3-5 years and 6-10 years. Tree species composition and geography had no effect.

Using our data, combined with observations on accumulation of leaf litter layers and changes in soil surface texture with time, we have constructed a dynamic model of the effects of invertebrates on soil hydraulic properties that are likely to benefit tree growth and survival. This synthesis represents the first step in defining and testing management actions aimed at enhancing delivery of the ecosystem function of water infiltration.

See also: Bourne *et al.*, in this issue, pp 19-20.

# Linking the above-ground to the below-ground: why we should be restoring processes as well species in our revegetation efforts

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*'Presently they all sat down to luncheon together. The mole found himself placed next to Mr Badger, and, as the other two were still deep in river gossip from which nothing could divert them, he took the opportunity to tell Badger how comfortable and home-like it all felt to him. "Once well underground", he said, "you know exactly where you are, nothing can happen to you, and nothing can get at you. You're entirely your own master, and you don't have to consult anybody or mind what they say. Things go on all the same overhead, and you let 'em, and don't both about 'em. When you want to, up you go, and there the things are, waiting for you". The Badger simply beamed on him. "That's exactly what I say", he replied. "There's no security, or peace and tranquility, except underground" ….'*

From: Grahame, K. (1908) *The Wind in the Willows*. Methuen and Co. Ltd, London.

### The restoration vision

Restoration of Australian woodland ecosystems has clearly gained significant momentum over the past decade or so, through excellent initiatives by organisations such as Greening Australia and Landcare Australia. For the most part, on-ground works have been conducted under voluntary schemes, with many pairs of dedicated hands tirelessly planting seedlings, erecting protective fences or shoring up eroded soils. While the objectives of these groups are as varied as the places they strive to ameliorate, the vision is much the same: 'bringing back trees', 'repairing and viably managing the landscape', 'rehabilitating and preserving biodiversity', 'engaging the community in vegetation management to protect and restore the health, diversity and productivity of …. landscapes', 'creating a healthy, diverse and productive environment treasured by the whole community', and so on. Heady stuff, but how is the performance of these programs being measured, particularly after so much expended energy (not to mention goodwill)?

One measure of success in restoration programs of the kind described above is the number of seedlings put back into the soil per annum. Sometimes the numbers can be quite impressive – literally in the millions! Similarly, the area of previously cleared land put back under native vegetation in a given period of time can be used, as can the area of native vegetation added to the existing conservation network. Again, the numbers can be quite significant, in the order of many hundreds of square kilometres replanted, or tens of thousands of hectares protected. Finally, the degree to which the community is engaged in restoration works can be stated in terms of number of volunteers used, the number of education days or the number of community interest and school groups consulted. Together, reporting against these attributes enables the full worth of the revegetation schemes to be highlighted, albeit from a human perspective. But are these measures enough in themselves to assess whether the works conducted have helped recreate the viable landscapes that remain at the core of the restoration vision?

Of course, the answer to such a deliberately narrow-framed question is a resounding no, and many scientists are working in collaboration with revegetation teams to better understand what we are getting in terms of 'value for money' for our collective efforts. However, to-date, most of these research endeavours have been more an exercise in stamp collecting, focussed on lists of readily visible species, rather than gaining a true or deeper understanding of how well or otherwise the ecosystem has been repaired.

### Above-ground

There can be little argument that the vital first step in appreciating the value of restoration works is to document the range of species found on-site. This will be an amalgam of the species that existed before the ameliorative efforts, plus the species brought back into the system by the hand of humans, plus the species that have since found a way

*Swamp Wallaby, a mycophagous mammal.*
*Photo: Karl Vernes*

back into the system through natural dispersal and/or immigration. If we are lucky, the inventory of species will include at least the plant species and most vertebrate groups, though with the latter the tendency has been to prepare lists of bird species. In itself, a list of birds is a great thing and, lets face it, birds are easily visible, mostly taxonomically well sorted out and therefore identifiable, and to a lesser extent perhaps indicative of a set of prescribed environmental conditions.

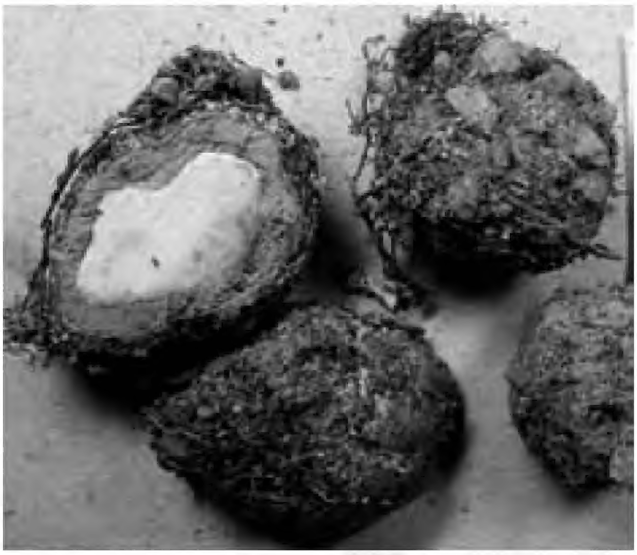
Concentrating on birds has lead to the so-called 'focal-species approach', in which assemblages of birds are used as surrogate measures of environmental health. What these vertebrate assemblages do not do, however, is provide an indicator that ecosystem processes have been fully restored – they simply give the illusion that the system is once again healthy because there are sufficient other resources to support them at the time. For example, the presence of a thornbill and other small (near-ground) birds might indicate that the density of understorey vegetation at a site is thick enough to provide shelter and foraging substrate. Identifying the presence of these birds does not, however, capture whether the system is now again resilient, or able to cope with stress such as drought. Only when the thornbill or the other small birds 'disappear' do the alarm bells ring.

### Below-ground

Unfortunately, appreciating whether woodland processes have been fully restored, rather than the species merely reintroduced, demands that we work from the soil up – not the trees down. This is much harder since many of the microorganisms, and indeed macroorganisms, that either live in or interact with the soil are poorly understood and mostly undescribed. For many years this has been held up as the primary impediment to learning more, since taxonomy is typically viewed as the starting point for understanding nature and natural processes – a foundation stone, if you like. The downside is that our knowledge of the soil has really gone backwards, in relative terms, proportionate to our efforts in describing above-ground features.

The lack of attention paid to below-ground organisms is particularly ironic since for several centuries it has been recognised that the prosperity of trees depends on a range of fungal associates – in the form of a symbiosis termed a 'mycorrhiza' (literally translated as 'fungus-root'). Mycorrhizal fungi are adept at capturing nutrients and water from the soil and transferring them to the host plant. Some of them provide physical protection to the root system, forming an outer sheath, which further confers drought resistance, while others produce chemicals to inhibit root pathogens such as *Phytophthora*. In return the fungus receives carbohydrates from the plant. In short, each partner is dependent upon the other.

In more recent times it has been established that there is usually a third party that enhances the symbiosis between plants and fungi – in the form of animals that eat and then distribute the latter. These mycophagous (fungus-eating) animals include a diversity of ground-dwelling mammals, as well as invertebrates and to a lesser extent birds and reptiles. Mycophagy by mammals is best understood. Different mammal species have varying nutritional dependencies upon fungi, but the fungi that they do consume are predominantly the underground fruit-bodies of truffles or false truffles, which are nearly all mycorrhizal. Truffles are comprised mostly of indigestible spores, supported by non-reproductive tissues that are differentially digested. In ingesting the spores, the mycophagists play a vital role in dispersing them later in faecal pellets, somewhere away from their source colony. In this way genetic mixing among truffle populations is ensured. Several studies have shown that spore laden faecal pellets of mycophagous mammals are excellent sources of mycorrhizal inoculum, particularly when they are placed in close proximity to host plant rootlets.



*A truffle-like fungus,* Mesophellia. *The interior of the fruit-body is filled with spores around a sterile core, and the outer layer contains mycorrhizal plant rootlets. Photo: Karl Vernes*

In foraging for truffles, mycophagous mammals also provide engineering solutions for the soil and woodland environments they live in. First and foremost, where they dig they create open pits into the soil profile. Studies in Western Australian woodland systems have shown that such pits are preferential entry points into soil for rainfall and sub-surface runoff of water, as well as for nutrients and organic matter from the leaf litter. This is particularly important since most Australian soils are naturally hydrophobic, low in key nutrients and poor in organic matter. In areas where mycophagous mammals have been particularly active, the soil is often pock-marked with many excavations and, as a result, is friable. In short, such a soil environment is favourable for the activity of many soil micro-organisms involved further in nutrient acquisition, including mycorrhizal fungi. Through the foraging action of mammals such as bandicoots, bettongs and potoroos, the soil is maintained in a healthy state. Where such species go missing, soil properties may decline, though often these changes are further complicated by other factors such as loss of vegetation cover and alienation to agriculture.

Finally, the natural composition of woodlands may also be altered by way of other dietary behaviours of mostly mycophagous mammals. For example, in the woodlands of Western Australia, Brush-tailed Bettongs (*Bettongia penicillatta*) also play a role in dispersal of plant seeds, most notably that of Sandalwood (*Santalum spicatum*), which they collect and store in food caches well away from founder trees. In this way, the dispersal of sandalwood is ensured, since not every removed and re-deposited seed is eaten and even bettongs can be forgetful of where they leave their food pantries! Thus, new seedlings and even thickets of sandalwood can appear and, in some cases, replace ageing or dying trees.

There is no question that planting trees, fencing off land and halting soil erosion are necessary activities for restoring woodlands and people involved in this work should be congratulated. What should not be lost in this success story is that current restoration efforts are merely first steps on a very long journey. If woodlands are to be made viable for the long-term, it will be necessary to restore vital ecosystem processes to these fragile landscapes as well as species. The interrelationships among plants, truffles and mycophagous mammals exemplify the sort of ecological fabric that needs to be re-established – the glue that helps bind the rest of the system together and offers resiliency in changing times.

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# Ectomycorrhizal fungi – vital components of Australia's natural and restored biodiversity

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Mycorrhizal fungi partner 80% or more of land plant species (Wang and Qiu 2006). The fungi convey multiple benefits to the plants including enhanced uptake of nutrients from poor soils. Many plant families in Australia such as Casuarinaceae, Ericaceae (formerly Epacridaceae), Fabaceae, Nothofagaceae, Myrtaceae and Orchidaceae are mycorrhizal. Mycorrhiza are absent or rare in only a few major Australian plant families, such as Proteaceae and Cyperaceae, which have adopted other strategies to extract nutrients from poor soils such as producing cluster roots.

There are many types of mycorrhizas. Arbuscular mycorrhiza (AM) are the most prevalent type and they occur with the majority of present-day land plants (Wang and Qiu 2006). The various types of mycorrhiza are recognised by their root structure and specificity with particular plants, e.g. those exclusively associated with epacrids, liverworts, or orchids. Ectomycorrhiza (ECM) differ from other types of mycorrhiza by producing a sheath around the fine roots and penetrating between the root cells rather than into the cells. Most types of mycorrhiza, including AM and orchid mycorrhiza, are formed by microscopic fungi. However ECM are formed by macrofungi (Figs 1-4). A high diversity of ECM fungi occurs in Australia, and the majority of the species are unique to this continent. In Australian forests and woodlands ECM fungi are associated with many of the dominant woody trees and shrubs.

### ECM contribute to long-term sustainability of terrestrial ecosystems

ECM fungi interact with plants and animals in a range of beneficial ways that contribute to the long-term sustainability of ecosystems (Brundrett 2002). Fungal filaments (hyphae) radiate out from ECM roots into the soil. They access and retrieve phosphorus and other nutrients from soil. Within ECM roots a two-way exchange occurs. The fungus delivers soil nutrients to the plant and the plant provides sugars from photosynthesis to the fungus. Hyphal networks (mycelia) are more intricate than plant roots and can exploit more of the soil. Exudations from hyphae may transform some nutrients tightly bound to soil into forms that can be assimilated. Generally it is considered that benefits to the mycorrhizal plant outweigh the effect of losing a portion of its photosynthates.

Enhanced nutrient uptake is one direct benefit of ECM to plants. However in natural ecosystems any improved

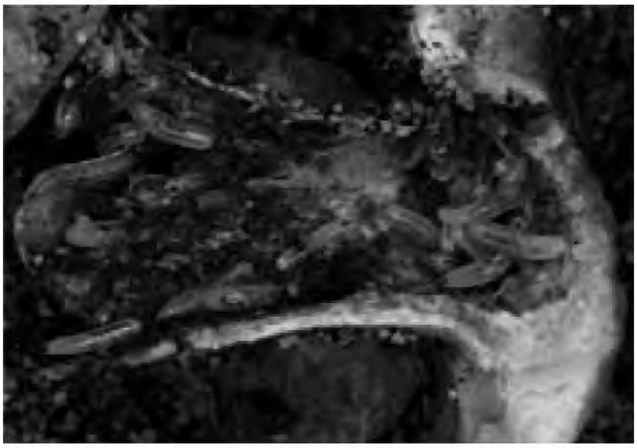

*Figure 1. The fruit bodies of ectomycorrhizal fungi provide food and/or habitat for many animals, such as these maggots of an unidentified insect inhabiting a species of* Tricholoma*. Photo: Neale Bougher*

growth or fecundity of plants attributable to ECM is not likely to be consistent, visually obvious, or easily measurable. Any such effects are likely to be confounded by other factors that affect plant growth or fecundity such as competition and grazing. The balance between plants and mycorrhizal fungi changes over the life of an individual plant – depending on factors such as prevalence, type, and number of mycorrhizal fungi linked to the root system at any point in time.

The mycelial networks of ECM fungi assist the distribution of nutrients throughout terrestrial ecosystems as they transport nutrients and carbon throughout soil, often far beyond roots. In some cases ECM networks may link different species of plants, or nitrogen-fixing plants to other plants. ECM networks bind soil and help to improve the soil organic matter. Some ECM fungi are also significant decomposers, such as those capable of colonising and rotting wood as well as forming mycorrhiza. ECM may buffer plants against environmental stresses such as disease. Mycorrhizal plants may be more robust than those without ECM, and also may be protected from soil-borne disease by the ECM sheath around roots.

ECM fungi also provide food and/or habitat for many animals. Truffle fungi produce their tuber-like fruit bodies below ground and depend on animals to disperse their spores. Truffle odours attract animals such as bandicoots, woylies, and potoroos which dig up the fungal fruit-bodies and eat them. The spores are unharmed when deposited in the animal's dung. A myriad of small organisms such as springtails and various beetles feed on fungal hyphae and use fungal fruit bodies as food and habitat for laying eggs (Fig. 1).

### ECM fungi

ECM fungi produce fruit bodies readily visible to the naked eye such as mushrooms, toadstools, puffballs, and coral fungi (Figs 2-3). Some ECM fungi have less conspicuous fruit bodies, such as truffles or simple flat crust-like fructifications (Fig. 4). Not all larger fungi are ECM; the majority of others are exclusively decomposers and some are pathogenic.

Production of fungal fruit bodies may be briefer and less consistent in drier regions of Australia such as woodlands than in wetter regions. In addition, in woodlands relatively few fungi may be observed by the untrained eye because many of the fungi fruit below-ground or barely emerge. This does not necessarily indicate that fewer fungi are present in woodlands. In both regions a diverse range of ECM roots and fungal networks may be active below ground.

Hundreds of species of ectomycorrhizal fungi are associated with dominant woody trees and shrubs in Australian forests and woodlands such as *Eucalyptus, Allocasuarina, Acacia,* and *Gastrolobium.* These and other plants may have only ECM, or have ECM and other types of mycorrhiza simultaneously or at different times. The ECM fungi can be a significant component of the species biodiversity of a given area of natural vegetation.

Native ECM truffles are mega-diverse in Australia with an estimated 2000 species, and about 90 genera and over 300 species currently known (Bougher and Lebel 2001). Most species of ECM fungi associated with native Australian

*Top: Figure 2. Many ectomycorrhizal fungi produce large fruit bodies that can be assessed visually in biological surveys, such as* Amanita umbrinella*.*
*Bottom: Figure 3. Some ectomycorrhizal fungi are known from few locations, such as* Amanita carneiphylla*. This fungus is formally listed as a priority species by the WA Department of Environment and Conservation. Photos: Neale Bougher*

plants are endemic to Australia. More than 35% of Australian truffle genera and 95% of species are endemic (Bougher and Lebel 2001). The distribution and abundance of most ECM fungi in Australia is unknown due to the low level of records. Many species may be widespread within broad climatic/vegetation regimes, but some fungi may be rare, e.g. some species of *Torrendia* known only from several small remnant woodlands in WA.

### Sensitivity of ECM fungi and the imperative to restore them

Each species of ECM fungus has particular habitat preferences and life-cycle attributes, and may respond to natural or human-induced environmental changes in different ways, just as do plant species. Most ECM occur in the organic layer near the soil surface. Hence disturbances such as fire and loss of litter can greatly affect them. Loss of host plants is a fundamental threat to their survival. Recovery of ECM fungi from disturbance has become a critical issue in some regions of Australia where only small, scattered patches of natural vegetation remain. Clearing has severely diminished opportunities for post-disturbance colonisation of fungi from elsewhere. This is especially critical in such regions where landholders are attempting to restore or expand the local natural remnant vegetation and to establish biodiverse native plantings on former broad-acre farmland.

In regions such as the central WA wheatbelt the few remaining good quality natural woodlands have a high diversity of ECM fungi. Degraded patches have fewer ECM fungi, and very few native fungi are self-returning to restored vegetation on former farmland (Tommerup and Bougher 2000; Bougher 2005; Stol and Trappe 2006). Exceptions include some invasive fungi that thrive after disturbance, such as the puffball *Pisolithus*. The remaining bank of native fungi in remnant natural vegetation is limited in the WA wheatbelt. In that region it seems probable that the fungi will take a very long time if ever to return to restored vegetation unaided.

ECM fungi may need to be assisted back in order to help re-establish the natural processes that have contributed to the sustainability of natural vegetation. Some methods to help promote the return of local fungi diversity and to avoid pitfalls such as introducing persistent weed fungi are now available (FungiBank at www.fungibank.csiro.au). Using local plants is a well-established premise for bush restoration, and this applies to fungi too.

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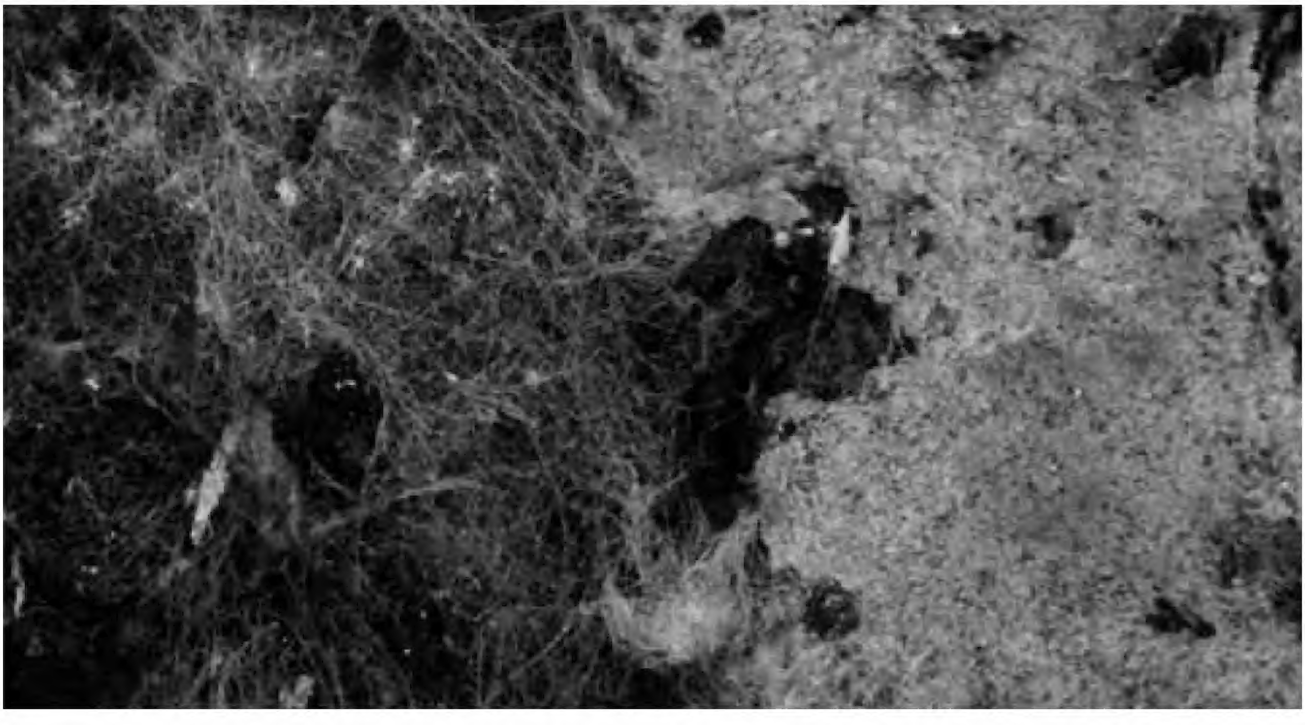

*Figure 4. Some ectomycorrhizal fungi have inconspicuous fruit bodies. This species of* Tomentella *forms simple flat fruit bodies on burnt wood but also produces mycorrhizas with eucalypts. Photo: Neale Bougher*

# Are diverse mammal communities important for maintaining plant-fungal associations and ecosystem health?

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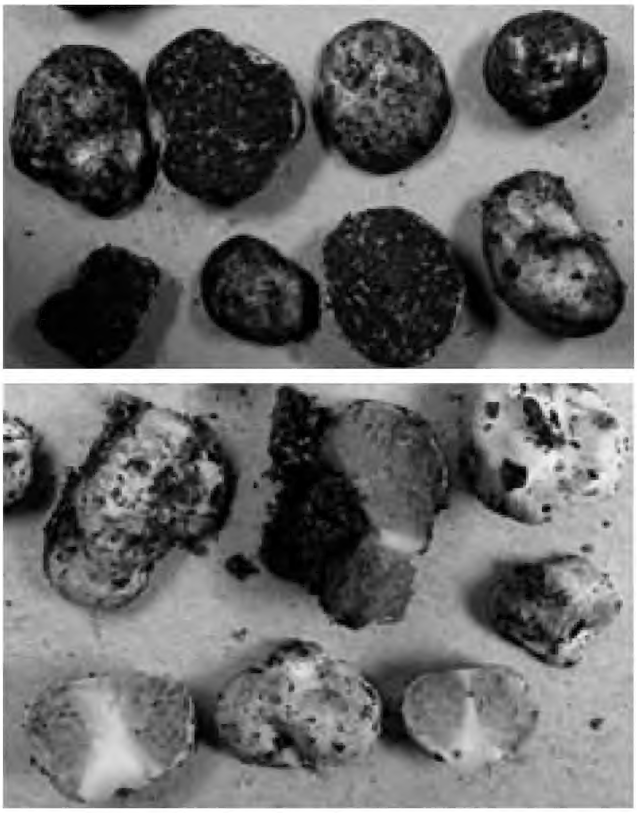
## Mammal-fungal relationships

The symbiotic relationship between mycorrhizal fungi and vascular plants has long been known to confer important benefits to plants, such as enhanced mineral nutrient uptake, drought-tolerance, and disease-resistance. In recent decades, the importance of mammals in excavating and ingesting hypogeous (below-ground) fruit-bodies of truffle fungi and dispersing their spores via faeces has gained great momentum. Truffles are mycorrhizal and therefore are particularly important in the ecosystem processes occurring below the soil, and how they are maintained. Andrew Claridge (this issue pp 11-13) highlights the importance of mammal-fungal relationships to forested ecosystems in Australia, and there are several excellent reviews on this topic (for example, see Johnson 1996; Claridge 2002).

The association between certain types of mammals and hypogeous fungi is found around the world; for example, squirrels and mice disperse fungal spores in northern hemisphere forests in much the same way as bandicoots, bettongs and potoroos do in Australia. However, similar to overseas, most Australian studies that have focused on mammal mycophagy ('fungus eating') have tended to focus on single species from mammal groups for which fungus was already known to form a significant proportion of the diet. So, considerable effort has been concentrated on the rat-kangaroos, bettongs and potoroos (Family Potoroidae), several native rodents (Family Muridae), and to some extent, the bandicoots (Family Peramelidae).



*Top: Truffle fungi (*Cortinarius*).*
*Bottom: Truffle fungi (*Octaviania*). Photos: Karl Vernes*

## A multitude of mammal mycophagists

Despite the attention paid to mycophagy in bettongs and potoroos, the diets of many Australian mammals have been largely ignored with respect to mycophagy. Another overlooked topic is the interactions of mammals in a community in terms of dispersing the multitude of fungi that occur in Australian forests and woodlands. Indeed, in most forested ecosystems, simple knowledge of which species of mammal consume fungi is lacking, not only because the basic ecology of some mammals is unknown but also because the consumption of fungus by mammals has often been historically overlooked in dietary studies.

In Australia, we should be more concerned about our lack of knowledge of how (and which) mammals consume and disperse fungi, because all evidence points to the community of our mycorrhizal truffle fungi being one of the most diverse on earth (Bougher and Lebel 2001). Presumably, a rich and diverse mycorrhizal fungal community contributes to a healthy and resilient forest ecosystem that may be able to respond to environmental change, such as the looming threat of global warming. It follows that a better understanding of how mammals interact with fungal diversity and ultimately which mammal species, or combinations of species, are key to maintaining or enhancing fungal diversity will undoubtedly be important for the long-term maintenance of fungal communities in the face of human-induced environmental change.

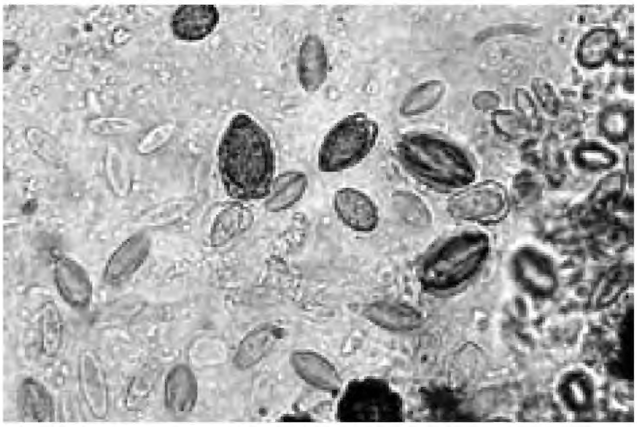
In the most comprehensive review of mammal mycophagy undertaken to date, Claridge and May (1994) compiled a list of Australian mammals reported to have consumed fungi as a part of their diet. Most of the species listed by Claridge and May are native rats and mice, and the rat-kangaroos, bettongs and potoroos. Notably, the list contained few macropods (the kangaroos, wallabies and their allies) – only six species from a total of more than 40 that between them occupy practically every terrestrial habitat across Australia.

Part of my current research has been to gain a greater understanding of which species of mammals eat fungi as a part of their diet, and disperse them via faeces. This work focuses on mycophagy in two mammal communities in northeastern New South Wales – a diverse community of 28 native and six introduced mammals (excluding bats) at Gibraltar Range National Park (see Vernes *et al.* 2006), and a simplified mammal community of 13 native mammals and eight introduced species at a fragmented forest site (the 'Newholme Field Laboratory') near Armidale. Work on the diets of mammals at these sites has revealed that mammal mycophagy is widespread, with 20 of 31 mammal species (65%) being mycophagous (Table 1). If we only consider mammals that forage for most or all of the time at ground level (thereby excluding the koala, and most of the possums), 19 of 24 (79%) mammals are mycophagous (Table 1).

Most of these mammals probably consume fungus as a small part of their diverse diet, but nevertheless, the numbers of species they consume suggest they are playing an important role in spore dispersal. For example, among the macropods at Gibraltar Range, Swamp Wallabies consumed more than 35 fungal taxa, and on average, about 72% of dietary samples contained fungal material. Parma Wallabies consumed 30 fungal taxa (84% of samples contained fungus), and Red-necked Pademelons consumed 27 fungal taxa (85% of samples contained fungus). Importantly too, the mammals at Gibraltar Range do not have fully overlapping diets when examined at the level of specific fungal taxa. In simple terms, this means that the different mammals, all consuming fungi, are not consuming exactly the same species. A diverse mammal community may therefore contribute to maintaining fungal diversity better than a simplified mammal community, although these kinds of ideas still need to be tested experimentally.

*Table 1. Species of mammal known from the study sites at Gibraltar Range National Park (GR), and Newholme Field Laboratory (NFL), with an indication of those recorded to consume hypogeous fungi at one or both sites.*

| Common and Scientific Name | Arboreal (A) or terrestrial (T) | Occur at GR | Occur at NFL | Consume hypogeous fungi? |
|---|---|---|---|---|
| **Monotremes** | | | | |
| Short-beaked Echidna, *Tachyglossus aculeatus* | T | x | x | |
| Platypus, *Ornithorhynchus anatinus* | T | x | | |
| **Marsupials** | | | | |
| Spotted-tailed Quoll, *Dasyurus maculatus* | T | x | | |
| Brown Antechinus, *Antechinus stuartii* | T | x | x | x |
| Yellow-footed Antechinus, *Antechinus flavipes* | T | | x | x |
| Common Dunnart, *Sminthopsis murina* | T | | x | x |
| Northern Brown Bandicoot, *Isoodon macrourus* | T | x | | x |
| Long-nosed Bandicoot, *Perameles nasuta* | T | x | | x |
| Eastern Pygmy-possum, *Cercartetus nanus* | A | x | | x |
| Feathertail Glider, *Acrobates pygmaeus* | A | x | x | |
| Sugar Glider, *Petaurus breviceps* | A | x | x | |
| Yellow-bellied Glider, *Petaurus australis* | A | x | | |
| Greater Glider, *Petauroides volans* | A | x | x | |
| Common Ringtail Possum, *Pseudocheirus peregrinus* | A | x | x | |
| Mountain Brushtail Possum, *Trichosurus caninus* | A/T | x | | x |
| Common Brushtail Possum, *Trichosurus vulpecula* | A/T | x | x | x |
| Koala, *Phascolarctos cinereus* | A | x | x | |
| Rufous Bettong, *Aepyprymnus rufescens* | T | x | | x |
| Long-nosed Potoroo, *Potorous tridactylus* | T | x | | x |
| Parma Wallaby, *Macropus parma* | T | x | | x |
| Red-necked Wallaby, *Macropus rufogriseus* | T | x | | x |
| Eastern Grey Kangaroo, *Macropus giganteus* | T | | x | |
| Common Wallaroo, *Macropus robustus* | T | | x | |
| Brush-tailed Rock Wallaby, *Petrogale penicillata* | T | x | | x |
| Red-legged Pademelon, *Thylogale stigmatica* | T | x | | x |
| Red-necked Pademelon, *Thylogale thetis* | T | x | | x |
| Swamp Wallaby, *Wallabia bicolor* | T | x | x | x |
| **Native Rodents** | | | | |
| New Holland Mouse, *Pseudomys novaehollandiae* | T | x | | x |
| Fawn-footed Melomys, *Melomys cervinipes* | A/T | x | | x |
| Bush Rat, *Rattus fuscipes* | T | x | | x |
| Swamp Rat, *Rattus lutreolus* | T | x | | x |
| **Totals** | | **31** | **20** | **20** |



*Left: Fungal spores from mammal scat. Highly magnified, individual spores are about 10 microns long.*
*Right: Red-necked Pademelon, a mycophagous mammal at Gibraltar Range (NSW) that consumes more than 25 different types of fungi. Photo: Karl Vernes*

## Mycophagy in modified landscapes

The Newholme Field Laboratory formerly had a more diverse mammal community that included one of Australia's most obligatory mycophagous mammals, the Long-nosed Potoroo. Over the last 150 years or so, mammal diversity at this site has been eroded by forest fragmentation and the ravages of feral cats, foxes, rabbits and hares, leaving a much-depleted fauna with no mycophagous potoroos, bandicoots or native rodents. What can the simplified mammal community at this site teach us about redundancy in a mammal community with respect to fungal consumption and dispersal? That is, are some of the remaining mammals able to 'fill in' for the missing species?

Although obligate mycophagous mammals for which fungus forms the bulk of the diet (e.g. potoroos) are gone, Swamp Wallabies still occur at Newholme, and appear to be the primary mycophagous mammal in the system, consuming a great range of truffle species across the site. Because Swamp Wallabies seem to cope well in modified landscapes dominated by feral species, including predators like foxes and cats, they (and resilient species like them) may be the dominant mycophagous mammals in places where more vulnerable, smaller mycophagous mammals, like bandicoots and bettongs, have vanished. Interestingly, small dasyurids that occur at Newholme (two antechinus species and one dunnart) are also mycophagous, and might be consuming surplus fungus in the absence of native rats and mice.

Although it is likely that Bush Rats once occurred at Newholme (the habitat is certainly consistent with where they still occur in other parts of the region) the site does not support any native rodents. However, we have recorded the introduced Black Rat (*Rattus rattus*) occurring as a naturalised population at low densities in Newholme's forested regions, far from the human dwellings typically associated with the species. Scats from the single Black Rat we have captured contained several truffle taxa, so Black Rats (and possibly other introduced species like the House Mouse *Mus musculus*) are possibly fulfilling the ecological role of truffle spore dispersal at this site previously carried out by native rodents.

## Conclusions

Given the ubiquity of truffle-forming fungi in Australian forests and woodlands, it stands to reason that a plethora of Australian mammals incorporate fungus into their diet. However, much remains to be learned about mycophagous mammals, even at the basic level of documenting which species of mammals consume fungus, and how many species of fungus they consume. Consumption and dispersal by such a wide variety of mammals, each with different habitat preferences, dispersal distances and truffle preferences means that relationships between mammals and fungi are likely to be more complex than previously thought. Whether mammal diversity influences fungal diversity, and how such relationships (or their breakdown) affect ecosystem resilience, particularly in light of human-induced changes, is still to be determined.

In relation to rehabilitation and restoration of native vegetation across Australia, important questions remain, in particular:

- what is the effect on truffle fungi (and therefore on the plants with which they form mycorrhizas) of the total disappearance of mycophagous mammals in some areas, and
- can a subset of the mycophagous mammals that used to occur in an area effectively disperse fungi, and which animals are most important in filling the gaps left by regional and local extinctions?

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# Soil and litter invertebrates, *Acacia* and plant growth in revegetated systems

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### The importance of soil and litter invertebrates

Soil and litter invertebrates strongly influence decomposition and nutrient cycling, and can have a profound influence on plant growth. Whilst it is recognised that the majority of primary decomposition is performed by microflora such as bacteria and fungi, the activity of microflora is greatly facilitated by invertebrates. This facilitation occurs in part through comminution (the transformation of organic material to smaller fragments) which increases the surface area available to primary decomposition. But there is also stimulation of microbial turnover by invertebrate grazing and the presence of microbial 'hot spots' in invertebrate guts and excrement (Brussaard *et al.* 1997).

The effects of soil and litter invertebrates on plant growth may be indirect (e.g. increasing nutrient cycling) and direct (e.g. root herbivory). Further, these influences on plant growth may be positive, negative or neutral. Figure 1 illustrates plant-invertebrate interactions in the soil and litter in the context of our study. These interactions change depending on context. The plant community may influence the invertebrate community directly through the provision of habitat such as litter. Plants also influence litter 'quality' (in terms of total nitrogen and carbon to nitrogen ratio), which may influence the composition of the invertebrate community and the litter decomposition rate. In turn, the influence of soil and litter invertebrates can affect the plant community.

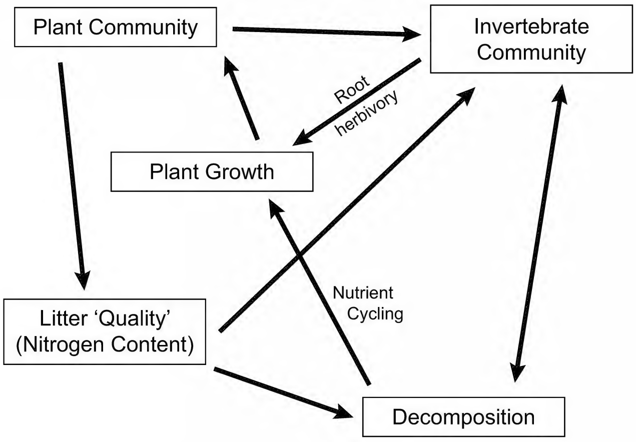

*Figure 1. Flow chart illustrating plant-invertebrate interactions in soil and litter. Arrows indicate the influence of one component on another, which can be positive or negative.*

### Our study

In our two-part study we 1) examined the role of *Acacia* in revegetated sites in terms of invertebrate communities and nitrogen input; then, 2) examined the role of soil and litter invertebrates in regulating plant growth by growing plants in pots. The study was conducted in mixed *Eucalyptus-Acacia* revegetation sites in north central Victoria, near Bendigo, Heathcote, Charlton and St Arnaud. The four sites had been planted between eight and 15 years ago with Grey Box *Eucalyptus microcarpa* and Golden Wattle *Acacia pycnantha*. Species of *Acacia* are commonly planted with *Eucalyptus* spp as 'nurse trees' due to their nitrogen fixing capacity, and have been demonstrated to increase growth of neighbouring *Eucalyptus* trees (e.g. Forrester *et al.* 2004).

### *Acacia* and invertebrates in revegetated sites

We found that in the revegetation sites *Acacia pycnantha* leaves and litter were a higher 'quality' in terms of nutrient composition (particularly nitrogen) than leaves and litter of *Eucalyptus microcarpa*. However, this was not the case for soil 'quality'. There were small, if any, differences in soil quality beneath these two tree species. This suggests that the nitrogen enrichment benefits of *Acacia* had not yet been expressed in the soil in the relatively short time since planting of these sites (8-15 years).

Litter quality was correlated with litter quantity. When there was more litter per area it contained more nitrogen. *Acacia pycnantha* tended to produce deeper, higher quality litter beneath it, and this influenced the invertebrate communities.

Invertebrate abundance responded positively to the quantity of litter – when there was more litter there were more invertebrates. Increased litter quantity provides more habitat for litter invertebrates, so this result was not surprising.

Some groups of invertebrates also responded to the nitrogen content of litter. For example, mites became more abundant as the nitrogen content of the litter increased. This meant that there was a consistent difference in the litter invertebrate community from beneath *Eucalyptus microcarpa* compared to that under *Acacia pycnantha*.

*Figure 2. Two of the revegetated sites included in this study, North-Central Victoria. Photos: Kim Pullen*

### Plant growth in relation to invertebrate communities

We grew plants in pots containing soil and leaf litter collected from the field sites. We killed the soil and litter organisms in half the pots in our plant growth experiment. A *Eucalyptus microcarpa* seedling was planted in each of the pots.

After about 100 days of growth we measured the differences between plant growth in the pots. We discovered that seedlings grown in pots with reduced soil and litter fauna grew less and had thin, flimsy leaves (measured by LMA, leaf mass per area). This exciting result showed that pots containing a normal soil and litter community were more favourable for plant growth than pots with reduced soil and litter fauna. This may have been due to increased provision of nutrients to the plant by the soil and litter fauna.

### Key messages and opportunities

This study showed the importance of the presence of a relatively undisturbed soil and litter community in improving ecosystem processes. Managing for a ‘good’ soil and litter community could have significant plant growth benefits. The addition of *Acacia* when replanting creates a litter mixture that promotes heterogeneity in litter quality and quantity and invertebrate communities, and therefore heterogeneity in ecosystem processes such as decomposition and nutrient cycling.

It is important to keep in mind though that soil nitrogen enrichment benefits from *Acacia* may not be expressed for a number of years. Also, it appeared that the soil and litter invertebrate communities in these revegetated sites showed low diversity compared with natural systems. This highlights the difficulty in restoring natural systems, and further enforces the principle of preserving existing native vegetation.

This type of study opens up opportunities for similar projects in revegetated sites. It was difficult to compare the invertebrate communities we observed to other revegetated sites due to the lack of information available on this topic in general. It would be useful to have data from a variety of systems to compare to. It would also be interesting to investigate how soil and litter invertebrate communities change after revegetation. Invertebrate communities from recently planted sites through to older sites could be examined. If there was opportunity for a long-term study, one could also examine how invertebrate communities change within sites over successive years.

Further plant growth experiments could look at plant growth over a greater period of time, and investigate growth of different plant species. An additional project could look at plant growth in larger pots or experimental plots that are growing both *Eucalyptus* and *Acacia.*

Further details of the plant growth experiment will be reported elsewhere. For more information regarding this project please contact the authors. The CSIRO Water for a Healthy Country Flagship provided financial support for this research. The contents of this article do not reflect the official policy of the NSW Department of Environment and Conservation, the NSW Government or any other agency or organisation.

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# Translocation of Leafy Greenhood *Pterostylis cucullata*

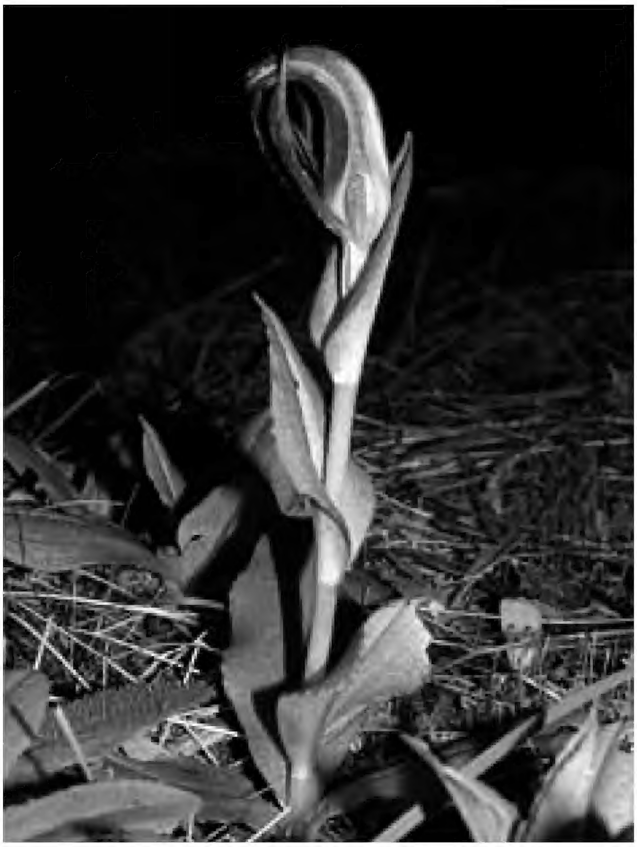
*Russell Mawson. Email: russell.mawson@bigpond.com*

*Pterostylis cucullata* (Leafy Greenhood) is a spring-summer flowering terrestrial orchid. In September / October 2004, I was told of a population of *P. cucullata* on private land on the Mornington Peninsular in Victoria. The owners had applied for a permit to clear trees, to allow for building their house. The shire representative inspected the site and *P. cucullata* was found within the building area. As this is a national and state listed plant under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* and the state *Flora and Fauna Guarantee Act 1988*, a permit for translocation from the Commonwealth Department of Environment and Heritage was required. I marked the area of approximately three square metres occupied by the main population, and estimated there were between 200 and 500 flowering plants. Almost six months elapsed before both the permit arrived and there was a convenient time for the translocation to start. Since the plants were no longer visible it was fortunate the markers were still there. The site was towards the front of the block and quite degraded. The soil was alkaline sand (ph 8.5-9) and easy to work.

### Removing and storing the plants

We chose the last week in February to dig the plants out. The first day saw four of us working, transferring the blocks of soil into styrene boxes which had a piece of shade cloth placed across the bottom. We used garden spades to cut squares of soil the width of the blade and about 2/3 the blade depth. As the day wore on and the number of boxes increased rapidly, we used our hands to sort the tubers. The sand was loose and dry and so tubers were easy to locate. The styrene boxes contained 75-100 mm of soil. The tubers were put onto this and were covered with a further 50-75 mm of soil. At the end of the day we had 34 boxes. On the second day, with three of us hand sorting, it took a bit longer and another 24 boxes were produced. Boxes were taken to my home to be stored and cared for until a site within Cape Schanck National Park was selected and approved for translocation. As room to store 58 boxes was limited I decided to hand sort, count and replant the tubers. This reduced the number of boxes to 34 with 1875 tubers between 4 and 20mm in diameter. Tubers under 4 mm were not counted.

*Gidja Walker, Imelda Douglas and Russell Mawson removing the tubers from the original site. Photo: Merril Halley*



Pterostylis cucullata *(Leafy Greenhood). Photo: Russell Mawson*

The boxes containing tubers were placed on benches in a sheltered area covered by bird wire and 50% shadecloth. This allowed natural watering of the plants, with approximately three additional hand waterings required over the next year. I had placed 48 of the larger tubers in one box and these were the first to emerge and flower in early June, the rest appearing, according to size, through to late November. There was a large number of flowers and about ten seed capsules were produced by natural pollination.

### Replanting

A site in the Cape Schanck National Park was chosen, taking into account vegetation, aspect and soil. Over the two days prior to planting all tubers were removed from the soil in the styrene boxes and washed to remove any remaining soil. This was done to help minimize the risk of introducing pathogens into the site. For locating tubers when planting, we used a 1 metre square piece of garden mesh, which had 10 cm squares. A peg was driven into the ground at each corner of the square to hold the mesh in place, and a numbered disc was attached to a corner peg. In each of the 10 cm squares a tuber was planted.

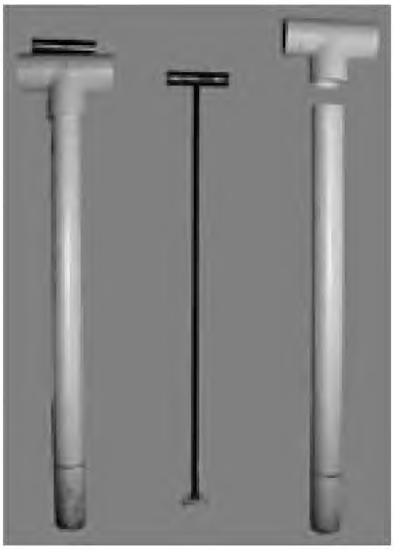
To limit the amount of soil disturbance, a planting device was constructed (see figure right). The device was not glued together, and so can be easily cleaned after use. The tube of the planting device was pushed into the ground approximately 70 mm and lifted out (with a plug of soil) leaving a hole into which tubers were placed. The tube was then put back into the hole and the soil plug was pushed out at the same time as the tube was pulled out. All the tools used were washed in Phytoclean before being taken into the site.

A few tubers had begun to shoot. If this new season's growth was likely to be damaged by the planting device, the tuber was placed so the new growth was at the side of the hole and the plug of soil was crumbled by hand to allow the soil to fall around the tuber. We began planting on 21 February 2006. Some 400 tubers were planted on that day, and by the third day 1400 tubers had been planted in the selected site. More tubers were planted approximately 10 m on the other side of the track from the first site. The plants were watered in and we also had rain within 7-14 days of finishing the replanting. The site has been looked at since and there is no sign of any major disturbance.

### Monitoring

This site will be monitored at least once a month over the growing season along with the other known sites in the area as a comparison for a minimum of two years. Further monitoring will be planned following analysis of the first two years results. In 2006, of the 1400 tubers in the translocation site, 1248 emerged. Some 306 plants produced flowers and 18 seed capsules were produced.

As knowledge of this orchid is limited, some tubers have been retained and planted to learn about multiplication, flowering rate and seed viability as well as providing a seed orchard should it be required. It is hoped this project will be successful. Time will tell. It is understood that translocating and reestablishing an orchid colony is a very high risk strategy and should only be undertaken if the orchids would otherwise be killed.



*The device used to plant tubers. Left: PVC pipe with rod inserted. Centre: 6 mm steel rod threaded at one end, with disc at base cut from 25 mm PVC pipe. Right: 25 mm PVC tube 50 cm long with depth line at base and 25 mm PVC 'T' at top. Photo: Russell Mawson*

### Acknowledgements

The Commonwealth Department of Environment and Heritage granted the permit for the translocation. The Natural Heritage Trust covered the cost of this translocation. The Department of Sustainability and Environment and Parks Victoria granted permits. The people involved with this project were: Victoria Purdue (University of Melbourne), Merril Halley and Kirsty Greengrass from DSE; Victor Teoh, Kris Rowe and Sue Mahoney from Parks Victoria; Gidja Walker, Imelda Douglas and Russell Mawson (also representing the Australasian Native Orchid Society, Victorian Group).

Left: *Sue Mahoney placing tuber into the hole at the new site. Right:* Pterostylis cucullata *appearing six months after translocation. Most of the broad leaves on the litter layer in the foreground are the* Pterostylis*. Photos: Russell Mawson*

# Environment (and agriculture) the big loser in closure of CRCs

*Rachel McFadyen and Jenny Barker*

*CRC for Australian Weed Management. Email: crcweeds@adelaide.edu.au*

Climate change is now firmly on Australia's political agenda, and among its predicted environmental impacts scientists warn of a fresh invasion of pest plants and animals and more intense and frequent bushfires. Yet against this backdrop of increasing environmental change and uncertainty, two of Australia's Cooperative Research Centres (CRCs) – the CRC for Australian Weed Management (Weeds CRC) and the Tropical Savannas CRC – are set to close in 2008. Their closure follows the wind-up in 2006 of the CRC for the Great Barrier Reef World Heritage Area, the CRC for Coastal Zone, Estuary and Waterway Management and the CRC for Tropical Rainforest Ecology and Management. The Weeds and Tropical Savannas CRCs recently failed in their bids for a third, seven year term largely because they could not meet the CRC Programme's strict commercialisation criterion, and the future of the Bushfire CRC is also uncertain.

The Australian Government announced a change in focus for the CRC Programme in 2004, restating its objective as 'enhancing economic growth through user-driven, co-operative public-private research centres that achieve high rates of commercialisation.' In other words, the CRC Programme placed greater emphasis on direct commercialisation processes such as spin-off companies and licensing products, a condition difficult for 'public good' CRCs to meet. In the wake of the decision not to renew the Tropical Savannas and Weeds CRCs, the CEO of the Bushfire CRC, Kevin O'Loughlin stated his concern that the CRC will fail to meet the tough new commercialisation criterion when it bids for its second term in 2008 (*Canberra Times* 6/1/07 'Threat to bushfire research'). Such is his concern that O'Loughlin has foreshadowed the possibility of foregoing the lengthy re-bid process to concentrate on establishing a permanent national research institute in fire ecology and forest research funded by universities and state governments.

The closure of these CRCs is not just a blow to the environment. The Weeds and Tropical Savannas CRCs also conduct important research for Australia's broadacre and grazing industries. In addition, Australia's agricultural industries have suffered a further setback with the CRC for Innovative Dairy Products also failing to secure a new term in the latest funding round. The Productivity Commission, the Australian Government body that reports on science and innovation, has been critical of the CRC Programme's move towards commercialisation and away from 'public good' research. The Commission recently recommended that 'the original objectives of the program – the translation of research outputs into economic, social and environmental benefits – should be reinstated. This is likely to produce greater community benefits than focusing public support on the commercialisation of industrial research' (Productivity Commission 2007). Unfortunately, these findings have probably come too late to resurrect the failed CRCs, and they must look to alternative funding sources to survive beyond their current term.

## Weeds CRC achievements and initiatives

With the impending closure of the Weeds CRC in little more than 12 months, it is fitting to look back at some of its achievements and initiatives, particularly in the environment sector, include the following:

### National partnerships

Established partnerships with key environmental research organisations including Adelaide University, CSIRO Entomology, CSIRO Plant Industry, CSIRO Sustainable Ecosystems, NT Dept of Infrastructure, Planning & Environment, Qld Department of Natural Resources & Water, SA Department of Water, Land & Biodiversity Conservation, University of New England and the University of Queensland.

### Nationwide expertise

Developed a world-class, nationwide network of researchers including internationally recognised leaders in weed management.

### National Weeds Advisory Group

Represented on the National Weeds Advisory Group which advises the Australian Government on weeds research and development.

### Biosecurity

Exposed a loophole in Australia's quarantine laws that would allow the importation of 125,000 plant species into Australia, amongst them 4000 known weeds, without any screening (Spafford *et al.* 2004). The Weeds CRC worked with Biosecurity Australia and the loophole was finally closed late last year.

### Weed Spotters

Detected new weeds through the establishment and training of a network of individuals with botanical expertise. To date, about 200 Weed Spotters have been trained and over 700 specimens have been submitted to the Queensland Herbarium.

**Early Warning System**

Implemented an arrangement with Australian herbaria for an early warning system to alert weed managers to the first indication of plant spread in a region or state. The system will integrate data from Australia's Virtual Herbarium.

**Weed risk assessment**

Developed decision-support tools for managing new weed incursions and strengthened weed risk assessment systems used in Australia.

**Biodiversity**

Produced the first report that quantifies the impact of alien plants on Australian biodiversity (Coutts-Smith and Downey 2006). The NSW-based report found that invasive plants are the biggest threat, after land clearing, to the survival of native species. The Weeds CRC is also reviewing the impact of weeds on threatened and endangered species and ecosystems nationally.

**Indigenous lands**

Worked closely with the Australian Quarantine and Inspection Service in a project to raise weed awareness on indigenous lands in NT and Cape York, Qld, employing two Aboriginal Liaison Officers to help coastal communities identify and respond to potential invasive plants.

**Environmental weed management**

Packaged and delivered a range of weed management information, working with the Commonwealth Department of Environment and Heritage to produce management guides for the Weeds of National Significance and Alert List for Environmental Weeds, as well as an Introductory Weed Management Manual. The Weeds CRC has also produced a series of Best Practice Management Guides for key environmental weeds.

**Reducing chemical reliance**

Researched and promoted integrated weed management tactics in the environmental and agricultural sectors to reduce costs, lessen chemical reliance and avoid herbicide resistance.

**Biocontrol**

Contributed to the successful release of biological control agents for weeds such as Blackberry, Bridal Creeper and Mimosa and conducted world-leading research into the science of biocontrol, with the results published in international scientific journals. The Weeds CRC also reviewed over a century of biological control in Australia, finding clear evidence of its cost-effectiveness in weed management (Page and Lacey 2006).

**Nursery/landscape industries**

Worked with the nursery/landscape industry and gardening media to inform them of the damage caused by invasive garden plants and the existence of state and federal laws regulating the sale and distribution of noxious weeds.

**Bushland Friendly Gardens**

Helped Australians choose environmentally friendly plants for parks and gardens through its Bushland Friendly Gardens website.

**School programs**

Led the national development of Weed Warriors, an education and awareness program that introduces school students to weed science. The Weeds CRC also developed Lord of the Weeds, a national competition for high school students to design a weed management strategy for their school or local area. Teaching resources and activities aimed at raising weed awareness amongst upper primary school students are available through the Weeds CRC's *Ghastly Guests* initiative.

**VET sector**

Prepared and delivered a range of resources needed by the Vocational Education and Training (VET) sector for competency based training in weed related areas.

**Media campaigns**

Raised community awareness via regular media releases and through established relationships with key journalists. Recent environmental press releases include 'Make your garden waterwise – but don't plant weeds!', 'Garden plant threat to native species', 'Weeds a catchment priority' and 'Prepare for climate change invaders'.

## New national weeds centre proposed

The Weeds CRC has been invited by the Australian Government to submit an alternative model for a new national weeds organisation. Major partners in the Weeds CRC have expressed their willingness to remain engaged and are backing the proposed new centre. If the proposal is successful, the Australian Centre for Weed Research will enable core collaborative research and delivery capacity to continue in the long term. If it fails, Australia will be without a national organisation to coordinate weed research and to package and deliver these results across the full range of private and public land use, including park managers, bushcare and landcare groups, local government, regional Natural Resource Management (NRM) bodies and farmers. Furthermore, many of the Weeds CRC's initiatives and the momentum and skills it has built up over the last 12 years will be lost. The proposal for the new centre is available on the Weeds CRC website (http://www.weeds.crc.org.au/main/weeds_crc_to_end.html).

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Page, A.R. and Lacey, K.L (2006). Economic impact assessment of Australian weed biological control. CRC for Australian Weed Management. *Technical Series* 10.

Productivity Commission. (2007). *Public Support for Science and Innovation (Research Report)*. Australian Government.

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*In the north and centre of Australia, where higher rainfall is expected under climate change, serious weeds such as A -* Acacia nilotica *(Prickly Acacia), B -* Lantana camara *(Lantana), C -* Annona glabra *(Pond Apple) and D -* Salvinia molesta *(Salvinia) are expected to further invade bushland and grazing country. Despite this, Australia faces the prospect of tackling an increasing weed problem without a national weeds organisation.*
*Photos: Salvinia and Prickly Acacia: Colin Wilson; Lantana: Andrew Clarke; Pond Apple: Peter van Haaren*

# Report from New Zealand Plant Conservation Network

*Bec Stanley*

*Email: rebecca.stanley@arc.govt.nz*

### A Seed Bank for NZ's threatened plants

In 2006 the New Zealand Plant Conservation Network announced the establishment of the seed bank for New Zealand's threatened seed. The engineering and environmental consultants MWH have sponsored the seed bank and it will be established this year at the Margot Forde Germplasm Centre at AgResearch in Palmerston North. The proposal for a long term seed storage facility (or seed bank) arose from an *ex situ* conservation workshop and a presentation by Steve Alton from Kew Garden's Millennium Seed Bank Project at the 2005 NZPCN conference. The establishment of a seed bank for New Zealand's threatened plants helps implement Target 8 of the Global Strategy for Plant Conservation. The NZPCN and Margot Forde Germplasm Centre are currently working on finalising a registration process for seed collectors and developing seed collecting guidelines based on Kew's Millennium Seed Bank guidelines.

### Involving the public in the threatened plant listing process

The Network website is making it possible for the general public to have their say in the next threatened plant list for NZ. The purpose of the 2007 NZ Threatened Plant Listing is to provide an accurate and up-to-date assessment of the conservation status of New Zealand vascular plants. This meets Target 2 of the Global Strategy for Plant Conservation. This listing will involve an assessment of New Zealand indigenous vascular plants using the NZ Threat Classification System (Molloy *et al.* 2002) and the IUCN Red data criteria. This project is being run as a partnership between the New Zealand Department of Conservation and the New Zealand Plant Conservation Network. Submissions may be made by anyone using a submission form on the NZPCN website.

### On-the-ground plant surveys

NZPCN in collaboration with the Queen Elizabeth II Trust, who help landowners protect significant natural and cultural features on their land, have secured funding and commenced survey for threatened plant populations that occur on privately owned covenants throughout New Zealand. The purpose of the project is to provide detailed advice to the landowners, on whose property the threatened plants occur, about how best to manage and monitor the species. It is also hoped that the QEII regional representative will learn about the species and what they look like, leading to further discoveries during covenant field work. The final survey reports will be held by QEII and the landowner.

### Reference

Molloy, J., Bell, B., Clout, M., de Lange, P., Gibbs, G., Given, D., Norton, D., Smith, N. and Stephens, T. (2002). Classifying species according to threat of extinction - a system for New Zealand, Threatened Species Occasional Publication 22, Department of Conservation, Wellington.

**View *Trilepidea*, the E-Newsletter of the New Zealand Plant Conservation Network:**

December 2006
http://www.nzpcn.org.nz/documents/Trilepidea-061221.pdf

January 2007
http://www.nzpcn.org.nz/documents/Trilepidea-070116.pdf

February 2007
http://www.nzpcn.org.nz/documents/Trilepidea-070227b.pdf

March 2007
http://www.nzpcn.org.nz/documents/Trilepidea-40-070320.pdf

April 2007
http://www.nzpcn.org.nz/documents/Trilepidea-070417.pdf

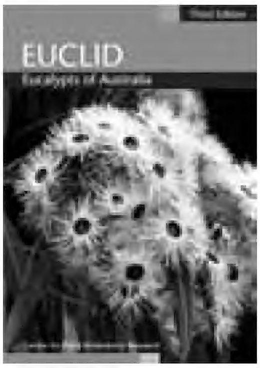
## Forthcoming issues of *Australasian Plant Conservation*

During the next year or so, forthcoming issues of *Australasian Plant Conservation* are planned on the following themes:

- **Taxonomy and Plant Conservation**
- **Conservation and Climate Change**
- **Community Plant Conservation** (conservation efforts by community groups)
- **Threatened Species Legislation and Processes Around Australia** (summary and analysis of commonwealth and states and territory threatened species legislation)
- **Trials and Errors** (reports of experiments that yield negative results and also documentation of revegetation and translocation trials)
- **Conservation of Woodlands**

Please contact the Editor (tom.may@rbg.vic.gov.au) if you would like to contribute to any forthcoming issues or be involved as a guest editor, or if you have ideas for future themes. General articles, not on the theme, are also always welcome.

# Book and DVD Review



## EUCLID: Eucalypts of Australia (Third Edition)

*Author: Centre for Plant Biodiversity Research*

*CSIRO Publishing, Collingwood, Victoria, 2006, DVD*, numerous colour illustrations.*
*ISBN 0643093354.*
*Price AU$120.00*

*System requirements: DVD drive, Windows 98/ME/NT/2000/XP; Minimum 32 MB RAM; 64 MB RAM or higher recommended; Internet explorer 5.0 or greater; SVGA monitor 800 x 600 or better

## Forest Trees of Australia (Fifth Edition)

*Editors: D.Boland, M.Brooker, G.Chippendale, N.Hall, B.Hyland, R.Johnston, D.Kleinig, M.McDonald & J.Turner*

*CSIRO Publishing, Collingwood, Victoria, 2006, 768 pages, numerous mostly black and white illustrations, hardback.*
*ISBN 0643069690.*
*Price AU$125.00*

**To order, contact publishing.sales@csiro.au**

These two publications, released within a couple of months of each other, look and feel like 'the old and the new'. The third edition of *EUCLID*, published on DVD, containing an interactive, computer-based key, copiously illustrated with high quality colour photos, and covering all 894 published taxa of 'eucalypts' in Australia, represents 'the new'. The fifth edition of *Forest Trees of Australia*, with a selection of 300 timber or other important trees, published in hardback with numerous, mainly black and white photos, and deliberately not adopting recent taxonomic treatments (such as the genus *Corymbia*) for some primary plant names, represents 'the old' (albeit updated).

EUCLID covers all taxa in the genera Angophora, *Corymbia* and *Eucalyptus* (family Myrtaceae) but is not a taxonomic revision. The aim is 'to produce a working key to all the eucalypts of Australia'. The authors state that they have not adopted the most recent published name for every species, but usually give reasons for those specific judgements which differ. Any particular species may be accessed either through lists of species in the section 'Browse species information' (where taxa are listed alphabetically both by scientific name and by common name) or from within the interactive key (using *Lucid* software) in the section 'Identify a eucalypt'. Clicking on a species name from either source immediately brings up an associated fact sheet.

*Forest Trees of Australia* (FTA) contains 178 'Eucalyptus' species and 121 non-eucalypts from 30 families. The latter include, for example, 12 'pine' species from three gymnosperm families, six sheoaks from the family Casuarinaceae, and 29 acacias from the family Mimosaceae. The species included have been selected for their environmental significance, their importance to the timber industry, or their prominence in the landscape. Families are presented alphabetically within the book, and, except for the eucalypts, species are covered alphabetically within families. Eucalypts are listed apparently randomly within the main subgenera or groups of eucalypts (e.g. Ghost gums, Bloodwoods), and thus the detailed index must be used to find the fact sheet on any particular species.

Despite their different presentation media, both EUCLID and FTA contain many similar types of information. To help the user understand terminology, both include background essays on plant morphology, well illustrated with photos and/or line drawings, and a glossary with often comparable associated illustrations. Each includes a fact sheet for every species that covers the common name(s), scientific name, a description of the plant (including habit, bark, juvenile growth, adult leaves, inflorescences, buds and fruit plus photos of each part), notes on key features or attributes distinguishing them from similar species, flowering times, and a distribution map based on known collection localities. Some differences are present in the fact sheets: only EUCLID gives a list of synonyms; FTA gives the origin of both the scientific and common names while EUCLID includes only the former; in the description, only EUCLID includes details of seeds and seedlings, while only FTA includes details of wood characteristics and uses and a summary of the climatic conditions over each species' distribution.

Other differences occur in the more general information provided. EUCLID includes sections that discuss hybrids or draw on recent molecular data to outline the evolutionary relationships within the 'eucalypts'. FTA includes sections that discuss the origin, variation and adaptation of Australian trees and the climatic, edaphic, biotic and other factors that control tree distribution, or that provide general background information on the major genera. It also outlines the distinguishing features and distribution of important tree families included in the book, and includes coloured photos of various vegetation types in Australia.

Perhaps the most important difference between the two publications is the presence or absence of keys. The sole key in FTA (on p. 203) relates to the various groups of eucalypts; it contains no keys to identify species. In contrast, the interactive key in EUCLID permits the user to readily identify a specimen (based on whatever material is at hand) if not to species, then to a small group of species. For those that have never used an interactive key before, the DVD provides a web link to a short tutorial that takes you step by step through a sample identification process using the key. Once you get the feel for how it works, the key is easy to use. At each step, there is a hot link to a description and illustration of almost every morphological character – an invaluable online tool that gives the novice confidence and the more experienced users timely reminders!

Your preference for either of these similarly priced publications will probably depend on your intended use. If your primary interest is in forest and other significant trees in Australia, and you want a basic reference that you don't want to lug out into the field, that you can dip into for information about particular species whose names you already know, *Forest Trees of Australia* will fit the bill. However, if your interest is solely in 'eucalypts', and you want both a comprehensive basic reference for information (including recent name changes) and a tool that will allow you easily to identify actual plant specimens (whether in the lab or in the field using a laptop with a DVD drive), then EUCLID will serve that purpose extremely well. In our household, we need (and regularly use) both publications!

*Rosemary Purdie, Canberra.*

# Research Roundup

Bannister, P. (2007). **A touch of frost? Cold hardiness of plants in the Southern Hemisphere.** *New Zealand Journal of Botany* 45(1): 1-33.

Belfield, S. (2006). **Naturally regrowing eucalypts is a challenge.** *Ecos* 33: 133.

Buchanan, R. (2007). **Providing operators and technicians for the ecological industry.** *Ecological Management and Restoration* 8(1): 3-4.

Byrne, M., Elliott, C.P., Yates, C. and Coates, D.J. (2007). **Extensive pollen dispersal in a bird-pollinated shrub, *Calothamnus quadrifidus*, in a fragmented landscape.** *Molecular Ecology* 16(6): 1303-1314.

Crawford, A.D., Steadman, K.J., Plummer, J.A., Cochrane, A. and Probert, R.J. (2007). **Analysis of seed bank data confirms suitability of international seed-storage standards for the Australian flora.** *Australian Journal of Botany* 55: 18-29.

Fischer, A. and Young, J.C. (2007). **Understanding mental constructs of biodiversity: implications for biodiversity management and conservation.** *Biological Conservation* 136(2): 271-282.

Gibbons, P. and Lindenmayer, D.B. (2007). **Offsets for land clearing: no net loss or the tail wagging the dog?** *Ecological Management and Restoration* 8(1): 26-31.

Hodgkison, S., Hero, J.-M. and Warnken, J. (2007). **The efficacy of small-scale conservation efforts, as assessed on Australian golf courses.** *Biological Conservation* 135(4): 592-602.

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Hylander, K. and Jonsson, B.G. (2007). **The conservation ecology of cryptogams.** *Biological Conservation* 135(3): 311-314.

Ladd, B. and Facelli, J.M. (2007). **Effects of neighbouring vegetation on eucalypt seedlings at two sites subject to different levels of abiotic stress.** *Austral Ecology* 32(2): 145-154.

Maron, M. and Fitzsimons, J.A. (2007). **Agricultural intensification and loss of matrix habitat over 23 years in the West Wimmera, south-eastern Australia.** *Biological Conservation* 135(4): 603-609.

McDougall, K.L. (2007). **Grazing and fire in two subalpine peatlands.** *Australian Journal of Botany* 55: 42-47.

McHenry, M.T. (2007). **A preliminary examination of White Cypress Pine management and soil and vegetation condition.** *Ecological Management and Restoration* 8(1): 61-63.

Myerscough, P.J. and Clarke, P.J. (2007). **Burnt to blazes: landscape fires, resilience and habitat interaction in frequently burnt coast heath.** *Australian Journal of Botany* 55(2): 91-102.

Nicol, J., Muston, S.D., Santos, P., McCarthy, B. and Zukowski, S. (2007). **Impact of sheep grazing on the soil seed bank of a managed ephemeral wetland: implication for management.** *Australian Journal of Botany* 55(2): 103-109.

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Tobe, K. amd Gao, Y. (2007). **Seed germination and seedling emergence of herbs in sand.** *Australian Journal of Botany* 55(1): 55-62.

Todarello, P. and Chalmers, A. (2007). **The characteristics of five species of hollow-bearing trees on the New South Wales Central Coast.** *Proceedings of the Linnean Society of New South Wales* 128: 1-14.

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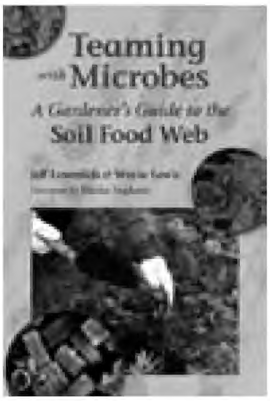
Yates, C.J., Elliott, C., Byrne, M. Coates, D.J. and Fairman, R. (2007). **Seed production, germinability and seedling growth for a bird-pollinated shrub in fragments of Kwongan in south-west Australia.** *Biological Conservation* 136(2): 306-314.

# Information Resources and Useful Websites

### Teaming with Microbes: A Gardener's Guide to the Soil Food Web

*Jeff Lowenfels and Wayne Lewis, 2006, Timber Press*



Smart gardeners know that soil is anything but an inert substance. Healthy soil is teeming with life – not just earthworms and insects, but a staggering multitude of bacteria, fungi, and other microorganisms. Chemical fertilizers can injure the microbial life that sustains healthy plants. However, there is an alternative: to garden in a way that strengthens, rather than destroys, the soil food web – the complex world of soil-dwelling organisms whose interactions create a nurturing environment for plants. By eschewing jargon and overly technical language, the authors make the benefits of cultivating the soil food web available to a wide audience, from devotees of organic gardening techniques to weekend gardeners who simply want to grow healthy, vigorous plants without resorting to chemicals. Published by Timber Press, http://www.timberpress.com/. Available in Australia from Bloomings Books, RRP AU$44.95, http://www.bloomings.com.au. 196 pp, with 74 color photographs and 17 charts and diagrams. ISBN 9780881927771.

### Planting Companion - A guide to native revegetation in the ACT region

*Compiled by Lori Gould, Greening Australia Capital Region*
*ACT Forests*

This publication draws together the experience and expertise of many revegetation practitioners around the country. It gives a wide range of useful information on topics such as site preparation, species selection, monitoring and evaluation and a guide to revegetation costs.

The Planting Companion is available for $10 (an additional $5 applies if postage is required). Please phone Conservation and Land Management (Territory and Municipal Services) on 02 6207 2145.

Further information: admin@act.greeningaustralia.org.au.

### Global Restoration Network

*http://www.GlobalRestorationNetwork.org*

This interactive website is rich with data, information, expertise and the latest techniques and innovations in restoration. Users can now find the exact information they need to research, implement and improve their ecological restoration projects. A specially designed database allows users to conduct efficient searches by entering specifications such as the type of biome (wetland, grassland, etc), region of interest, source of degradation, and more. Search results include annotated links to the most relevant resources including literature, case studies, data sets, white papers, organizations, government resources and restoration experts.

The GRN also offers lists of potential funders, educational and volunteer opportunities, video and audio feeds of Restoration Radio programs/interviews, descriptions of current and past restoration projects, thousands of links to restoration websites and blogs, and a growing directory of industry experts.

The website is hosted by the Society for Ecological Restoration (SER) International, whose mission is to promote ecological restoration as a means of sustaining the diversity of life on Earth and reestablishing an ecologically healthy relationship between nature and culture. SER was founded in 1988, by a diverse group of people including biologists, ecologists, philosophers, ethicists and community activists. Today SER has more than 2,000 members worldwide and Independent Chapters in regions such as Australia, Canada, Europe, and Asia.

# Conferences and Workshops

### FUNGIMAP IV Conference

*1-4 June 2007, Natural Bridge, SE Queensland*

Fungimap is a community group dedicated to conserving Australian fungi and improving knowledge about them. Activities include a fungi mapping scheme. The Conference will consist of a day of talks, followed by three days of fungal forays and workshops, including a trip to Lamington National Park. Activities are tailored for all levels of expertise, from beginners to experts.

Contact: fungimap@rbg.vic.gov.au

### Biodiversity: Balancing Conservation and Production - case studies from the real world

*26-28 June 2007, University of Tasmania, Launceston campus*

Scientists, producers from land and water, academics and planners now have experience to indicate that biodiversity conservation and profitable production are compatible, not antagonistic. Tamar NRM in association with the Centre for Environment, University of Tasmania presents a conference on 'Biodiversity: Balancing Conservation and Production', including case studies from the real world.

Case studies are wide-ranging and all linked to the promotion of biodiversity and production benefits. They include:

- harvesting kangaroos
- forestry prescription for individual species (Great Velvet Worms)
- profitably integrating high level biodiversity goals in contemporary farming
- multi-purpose tree growing
- regenerative agriculture
- irrigation and biodiversity.

The Conference aims to:

- bring together practitioners in production and conservation (in fisheries, agriculture and forestry) with scientists and policy makers;
- allow knowledge exchange based on practical 'on-ground' work and research through case studies;
- enhance understanding of integration and interdependence of land and water systems;
- improve planning processes at local government and agency levels;
- share and utilise to maximum purpose the knowledge, experience, convictions and commitment of participants;
- increase participation in, and understanding of, NRM strategies and principles; and
- ensure full involvement of younger participants – recognising the significance of 'intergenerational equity' within sustainability.

There will be a Public Forum 'Footprints to a sustainable future'.

Further information http://www.conferenceplus.com.au or email: Luba.Richards@conferenceplus.com.au

### Conserv-vision, the next 50 years: an international conference on conservation of biodiversity and historic resources

*4-7 July 2007, University of Waikato, Hamilton, New Zealand*

This conference celebrates 20 years of integrated conservation management by the New Zealand Department of Conservation.

The goals of the conference are to bring together practitioners, scientists, policy-makers and conservation advocates from New Zealand and elsewhere to:

- consider future challenges for conservation agencies and how existing models might be strengthened or adapted to meet them;
- review and evaluate achievements of the past 20 years of conservation management in NZ; and
- assess ways in which conservation agencies might best achieve their goals in 2050 and beyond.

The conference will include key speakers, papers, workshops and field trips related to issues of conservation management and practice by private and public sector agencies. Presentations will range from the politics and philosophy of conservation, to practical issues of species management, community involvement and participation, and methods to enhance public appreciation and understanding of indigenous biodiversity and cultural heritage. An important focus of the conference is to bring together the key interdisciplinary perspectives required to achieve successful conservation of native biodiversity and cultural heritage.

See: http://www.waikato.ac.nz/wfass/Conserv-Vision/

### The Biodiversity Extinction Crisis, a Pacific and Australasian response

*10-13 July 2007, University of New South Wales, Sydney*

This is an inaugural Regional Meeting of Conservation Scientists, organised by the Australasian Section of the Society for Conservation Biology.

Special challenges in the Pacific and Australasian region include: island ecology, rising sea levels, changing rainfall, and land and water degradation. These issues are overlaid by the general problems of habitat loss and fragmentation, invasive species, pollution and over-harvesting. The conference will identify major problems for biodiversity conservation in the region, look for existing and potential solutions and establish links to global biodiversity initiatives.

There will be five major themes:

- Regional challenges (particular issues for our part of the world);
- Managing threatening processes of universal importance;
- Case studies of conservation in action, including biodiversity monitoring and assessment;
- Conservation science and policy; and
- Conservation science and the community (NGOs, indigenous people).

Further information: http://www.biodiversity2007.com. Email: biodiversity2007@icms.com.au

### MEDECOS XI 2007
### International Mediterranean Ecosystems Conference

*2-5 September 2007, Perth, Western Australia*

The program for MEDECOS XI will feature oral and poster presentations covering important contemporary topics of global interest (e.g. global change, conservation of threatened species and ecosystems, restoration ecology). Given Perth's location in a global biodiversity hotspot, the accompanying pre- and post-conference field trips will showcase some of Western Australia's unique flora and fauna, ancient landscapes and striking coastline.

The following themes will be addressed:

- defining a mediterranean ecosystem
- species and population ecology
- landscape ecology
- socio-cultural dimensions
- global change
- disturbance ecology
- invasive species
- ecophysiology
- conservation of threatened species
- conservation of ecosystems
- restoration ecology

For information, please visit http://www.medecosxi2007.com.au. The organising committee can be contacted via medecosxi2007@bgpa.wa.gov.au.

### International Society for Seed Science Meeting Seed Ecology II

*9-13 September 2007, Perth, Western Australia*

Seed Ecology and its many facets (such as dispersal, predation, seed banks, dormancy, germination) continues to be a growth area in plant restoration. Seed Ecology II provides a venue for seed practitioners to meet as a single research community, and will be of particular value to students and young scientists. The meeting will also foster cooperation between scientists from different countries and lead to closer integration between researchers working on specific aspects of seed ecology.

The latest and most exciting developments in seed ecological advances will be showcased, around the following topics:

- advances in seed dormancy and germination
- dispersal ecology
- conservation and restoration seed ecology
- soil seed bank dynamics
- applied seed ecology.

See: http://www.seedecology2007.com.au.

### 9th International Conference on the Ecology and Management of Alien Plant Invasions

*17-21 September 2007, Hyatt Regency Hotel, Perth, Western Australia*

This conference is organised by The Weeds Society of WA (Inc.) and is aimed at all those who are interested in invasive plants in natural areas.

The conference will cover topics such as:

- ecological, biological and biogeographical studies on invasive plants;
- the management of plant invasions;
- the development of multidisciplinary activities focussed on prevention of new incursions and management of existing infestations;
- appropriate legislation, public education and information; and
- any other relevant aspects of plants that invade natural areas.

More information: http://www.congresswest.com.au/emapi9.

# Conferences and Workshops (continued)

### WILDCARE National Conference 2007

*Volunteering for wild places, wildlife and cultural heritage*

*23-25 November 2007, Hobart, Tasmania*

To celebrate our 10th Anniversary WILDCARE Inc. is inviting volunteers, volunteer organisations, foundations, NGOs, government agencies and their staff to a conference in Hobart in November.

WILDCARE is a not-for-profit, volunteer organisation whose members provide time, effort, intellect and funding to a myriad of projects and programs in reserve management, visitor services, community education, for nature conservation (on both public and private land), rehabilitating and rescuing wildlife and supporting cultural heritage conservation, in partnership with state and local government and private landholders. WILDCARE is a keen promoter of cooperative partnerships with reserve managers, private landholders, wildlife managers and cultural heritage managers, with the aim of making a real difference in the real world. WILDCARE promotes sharing ideas, developing new approaches and lending a practical hand to others.

This conference presents the opportunity for volunteers, volunteer and other community organisations, volunteer program managers and staff from partner agencies to get together and take some time to build better ways to work together towards a healthy reserve system, a protected cared-for and rehabilitated environment and wildlife (plants and animals), protected and cared-for cultural heritage and sites and an educated and aware community.

Further information: Office@wildcaretas.org.au or visit http://www.wildcaretas.org.au.

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Mapping vegetation condition in the context of biodiversity conservation
*Philip Gibbons, Andre Zerger, Simon Jones, Paul Ryan*

An overview of methods used to assess vegetation condition at the scale of the site
*Philip Gibbons, David Freudenberger*

Landcare and private conservation trusts: Fertile common ground?
*Guy Fitzhardinge*

Integrating policy and science in natural resources: Why so difficult?
*S. V. Briggs*

Planting designs in ecological restoration: Insights from the Button Wrinklewort
*John W. Morgan, Paul J. Scacco*

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For more information visit **www.blackwellpublishing.com/emr**

To renew or subscribe, please contact the Australian Network for Plant Conservation directly.

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**Botanic Gardens of Adelaide , SA**

**Brisbane Botanic Gardens, QLD**

**Centre for Plant Biodiversity Research, ACT**

**Christchurch Botanic Gardens, Christchurch City Council, NZ**

**Department of Environment & Climate Change, NSW**

**Institute of Food and Land Resources, VIC**

**Redland Shire Council, QLD**

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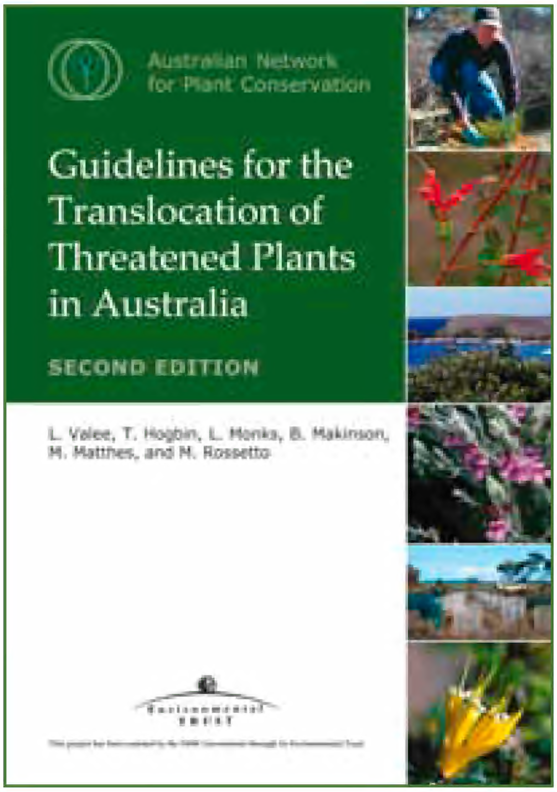

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